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ROYAL COMMISSION ON MATTERS OF HEALTH AND SAFETY ARISING FROM THE USE OF ASBESTOS IN ONTARIO

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VOLUME XVIII

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THE FURTHER PROCEEDINGS OF THIS
INQUIRY RESUMED PURSUANT TO ADJOURNMENT

APPEARANCES AS HERETOFORE NOTED

MR. LASKIN: I think we can start, Mr. Chairman, thank you. Mr. McNamee has indicated he will be about forty-five minutes late, so I believe we can begin.

DR. DUPRE: Well, may I welcome warmly one of the original and great friends of the Commission, Dr. Chatfield. Welcome back, sir. We are indeed in your debt for agreeing to come today to give sworn expert testimony.

Counsel, are there any points that you or your colleagues wish to raise before we swear the witness in?

MR. LASKIN: I don't believe so, Mr. Chairman.

DR. DUPRE: Miss Kahn, will you swear in the witness, please?

DR. ERIC J. CHATFIELD, SWORN

EXAMINATION-IN-CHIEF BY MR. LASKIN

MR. LASKIN: Mr. Chairman, Dr. Chatfield has been kind enough to prepare specifically for his testimony today a paper

MR. LASKIN: (cont'd.) which I have circulated not only to you, but to the parties. He is going to present the paper and amplify on it, and use slides.

For the record, can I put the paper in as an exhibit, and we already have a brief of Dr. Chatfield's articles. We are up to exhibit twenty-seven, so that for simplicity of reference can we make this new paper Tab Nineteen of Exhibit Twenty-seven?

EXHIBIT #27, TAB 19: The abovementioned document was then produced and marked.

THE WITNESS: I think if we go to the first slide, it's a reminder of the types of asbestos we are dealing with here. You see it divided into two different types of basic material, chrysotile and the whole set of amphibole asbestoses. As given in earlier briefs, the compositions of these things are somewhat variable, so that analytically we are not able to just measure, say, calcium and tremolite and assume that that is going to give us a measure of the tremolite. Quite apart from the fact that there are other materials present which may contain calcium, even the calcium concentration in tremolite is going to vary.

Now before we can define any analytical method for use in either workplace or environment, we have to say what it is we are trying to measure. This means that we should be looking at what fiber dimensions are biologically active, and what are also the minimum concentrations we are going to be asked to measure. A design of an analytical method is a little difficult if you don't know these two basic criteria.

The other thing is the precision of measurement. If we are going to count fibers, then the precision is almost entirely defined by the number of the fibers we count, and the precision that we are aiming at has a considerable bearing on the

THE WITNESS: (cont'd.) cost of analysis, and indeed its feasibility.

At this time the medical community has not really defined what are the range of fiber sizes which we ought to be including in the measurement. The carcinogenic potential has been shown, by part, in the next slide, please.

DR. UFFEN: Dr. Chatfield, do you mind a small interruption just for clarification, before you take it off?

THE WITNESS: Not at all.

DR. UFFEN: On the righthand side of the chart where you have crocidolite, the chemical formula is long and complicated. Just two quick questions. What does FE double one three...this is a nomenclature I don't know.

THE WITNESS: Oh, okay. The FE two is a divalent and FE three is trivalent form of ion.

DR. UFFEN: A similar question, the sodium appears in there. It doesn't appear in any of the others. Is that really just a...does sodium appear in the other asbestos forms?

THE WITNESS: It may do in small quantities, but the sodium in crocidolite is structural sodium, it's part of the structure, and indeed is our only means in many analyses of discriminating crocidolite from amosite. Magnesium doesn't occur in crocidolite either, in that composition, but if you take a sample of UICC crocidolite, you will find that magnesium is present as well.

DR. UFFEN: Oh, it is significant that the NA doesn't appear over in the chrysotile?

THE WITNESS: Oh, yes. Quite.

DR. MUSTARD: Could I ask a question as well?

Looking at chrysotile versus crocidolite on that slide, and the iron association of crocidolite distinguishes it sharply from chrysotile because you've got a lot more iron, because you don't have iron in the chrysotile, but you've got it

DR. MUSTARD: (cont'd.) in the crocidolite. The silicon/oxygen ratios are different between the two? Those are well-established facts, is it, that those ratios of silicon and oxygen...?

THE WITNESS: The silicon/oxygen, apart from the water. The water may be somewhat variable, but the silicon/oxygen ratios are certainly fact.

May I also mention that I don't put any iron in chrysotile, but you will undoubtedly find it. It's a question of a variable concentration of iron. The purest form of chrysotile, you will be able to get an iron-free chrysotile from California, it's made by Union Carbide or processed by Union Carbide. That you will not detect very much iron in, but other varieties you will see it.

DR. MUSTARD: Would the iron be much less than the crocidolite?

THE WITNESS: Very much less.

MR. LASKIN: The only question I have, and it's probably only me who is not certain what you mean, but the two criteria that you specified - biologically-important fiber dimensions, I can understand what you mean. What do you mean by minimum concentrations of interest should be specified?

THE WITNESS: If you are trying to do an analysis, then just putting it in context of the current school situation, we can do an analysis to any degree of sensitivity if we filter enough air through the filter.

There are one or two criteria, one or two things which will override that, and that's collection and the filter, etc. But we run into a problem if no one has said, look, provided it's below Concentration X, we are not concerned anymore. We are never able to demonstrate absolute absence. We can only say 'less than' a certain quantity, and that quantity may be defined by filter backgrounds or we may define it ourselves by saying

THE WITNESS: (cont'd.) look, we are just not going to look any longer than this in order to keep the analysis at a reasonable cost.

MR. LASKIN: I understand.

THE WITNESS: It seems to be generally agreed that the carcinogenic potential of a fiber is related to fiber dimensions. That automatically means that we have to be looking at a numerical count as an index of exposure, rather than actual mass concentration.

If size is important, then size has to be measured.

MR. LASKIN: Can we just stop there? I think, because we have had considerable difficulty, I think, understanding the testimony we have heard on fiber size and fiber dimensions and perhaps you can help us with it and perhaps relate it to this slide. Can we deal with both diameter and length, and perhaps we can deal with diameter first.

Am I correct, is it fair to say that the thinner the fiber in terms of diameter, the prevailing expert testimony seems to be, the more hazardous it is and the more dangerous it is from a health point of view?

THE WITNESS: From my reading of the literature, sir, including Stanton and Pott, would indicate that thinner fibers are the more toxic in that respect.

MR. LASKIN: Does that have something with the respirability of the fiber? That is, if it's a bigger diameter it can't get into the lungs? You don't inhale it?

THE WITNESS: Definitely. You'll find a paper by Timbrell, which I have with me, in which the falling velocity of a fiber is almost completely related to diameter and not to weight.

The smaller the diamter, the more readily... if it is a small diameter it would behave more like a small particle.

THE WITNESS: (cont'd.) The length doesn't come into this calculation in any significant manner.

MR. LASKIN: Is there a minimum diameter or is there a maximum diameter beyond which generally people will not inhale a fiber?

THE WITNESS: A maximum diameter? Hmmm, again you have to consider what is defined as a respirable particle at this point. Timbrell's paper, and others, have used ten micrometers equivalent unit as to spears, has been the limit of respirability. The smallest....sorry, the largest particle which is going to be considered to be respirable would be approximately ten micrometers in diameter. But that is a unit density particle.

Correction for other densities of materials would be made by dividing that diameter by the square root of the density.

Timbrell has shown that the...if we use a ten micrometer criteria here, a ten micrometer unit density criteria for respirability, then three to three and a half micrometers would be the maximum diameter that we should be considering as a respirable particle.

However, the EPA...and again, another document... have recently defined respirable particles as being fifteen micrometers, on the basis of mouth breathing rather than nose breathing.

MR. LASKIN: Could you, just for the benefit of the people back there, perhaps if you can...they may have a little difficulty hearing you.

MR. PIUZE: Yes, I would like, Mr. Chairman, if possible, if you could increase the volume of the equipment that you use, or speak a little louder. Maybe it's my age, but I'm missing part of it.

MR. LASKIN: We'll do what we can. They are not microphones, they are speakers for the transcriber for the recorder.

MR. PIUZE: Oh, I see. Well, I am missing part of it anyway...and the best part.

MR. LASKIN: Is there a prevailing expert view as to...in terms of diameter only, I'll come to length in a moment... but in terms of diameter only, what diameter is more hazardous than another diameter? I mean is there some particular diameter range that current expert opinion would say is more hazardous than another?

I'm not putting the question very well, but...

THE WITNESS: Again, I can only comment on the published literature, but Pott has, in fact, summarized what seems to be known of this topic, and it does go for, the potential for harm here does go through a maximum in his data, and then falls again with decreasing diameter.

MR. LASKIN: Is that on the...?

THE WITNESS: That's on the slide.

MR. LASKIN: That's on the slide. All right, we'll come to that.

Just briefly in terms of length, is it the short fibers that we have to worry about, or the long fibers that we have to worry about, to put the question simply?

THE WITNESS: Frankly, I don't know. There are a number of questions. If you take Pott's data and Stanton's data, you would say that the long fibers are the ones which we are concerned with.

If you then consider that is on a single-fiber basis, if you then consider that any size distribution of fibers... in any size distribution of fibers or particles, they are logarithmic normally distributed and there are many more small ones than large ones, and so even though one may have a reduced single fiber effect, there are a lot more of them in the smaller sizes. So the experiments that have been done using either long fiber or short fiber seem to be...you can criticize them on both counts.

MR. LASKIN: So what you are saying is, looking at any particular individual fiber that the longer ones may tend to be more hazardous than shorter ones, but in any fiber distribution or in any environment there are many more smaller fibers than longer fibers?

THE WITNESS: That's the way I would interpret it.

MR. LASKIN: Which is the counter...the other side of the coin.

Could you...could we put that slide back on?

Dr. Chatfield, could you just explain what the slide shows?

THE WITNESS: What Pott is trying to do in this slide is to collect together all of the data that has been done at that particular date of 1978, on carcinogenic activity of fibers.

He has plotted length and diameter on the base plane of...like a table divided into squares, and if you view that as a three-dimensional curve he is saying that the effect at, say, one point two five micrometers in length is not very large, but then it gradually increases to some value by the time you get to twenty micrometers or forty micrometers in length. That's looking along the horizontal part of the plane.

If you look along the diameter axis, then you will see that the peak seems to occur at about point one two five micrometers...point two five, perhaps...so he is saying that the potency goes through a peak as you go from point zero zero three one through to twenty micrometers...sorry, two point zero it is there.

MR. LASKIN: Is the carcinogenicity factor, is that an arbitrary scale or is that related...

THE WITNESS: That's an arbitrary scale.

MR. LASKIN: Can you relate that figure one to what we can measure in the optical microscope, in the workplace?

THE WITNESS: As far as the length axis is concerned, the optical microscope resolution doesn't come into the problem. But as far as the diameter axis is concerned, we would have to say that point two micrometers on the diameter axis is the lowest we are going to see optically using the best quality research microscope.

It is possible that many microscopes are not actually seeing much better than point four micrometers in diameter, whatever those fiber lengths may be.

MR. LASKIN: If you've got a fiber that's twenty micrometers in length, but has a diameter of point two, does that mean that you are not going to see it on the optical microscope?

THE WITNESS: Some operators would, some operators wouldn't. This is on the absolute limit of optical visibility.

The optical visibility is defined by the wavelength of light, and if you look at the textbooks on optical microscopy you will see that point four is approximately the limit for the ability to separate two features. The ability to see a feature seems to be limited to point two. There is, in fact..we are, in fact, working there at the absolute limit of optical visibility.

MR. LASKIN: In...and I appreciate measurements no doubt will vary from workplace to workplace and environment to environment, but I take it you yourself have looked at and have measured the percentage of fibers visible in the optical microscope or used as an index for workplace standards, as opposed to a total number of fibers that are actually there...have you done some of those measurements?

THE WITNESS: We have done a little bit of this kind of work, looking at size distributions in airborne dust clouds of this kind.

MR. LASKIN: What do you generally see and what

MR. LASKIN: (cont'd.) percentage of the fibers visible in the optical microscope or used as the basis of a standard are you actually measuring, as compared to the total number of fibers present?

THE WITNESS: The total number. Well, a proportion of the total number. The workplace measurement may only see perhaps one or point one percent of the total.

MR. LASKIN: When you say total fibers...perhaps I should have been more specific...is that total asbestos fibers?

THE WITNESS: Total asbestos fibers.

DR. MUSTARD: May I ask a question about the sources of Pott's data? Is the data based on carefully sized fibers administered to animals in controlled experiments to determine carcinogenicity, or is it an extrapolation from all the data on humans with all the limitations that that has in terms of estimation of fiber and estimation of response?

THE WITNESS: I think his data is basically from animal work, and largely leaning on the Stanton work.

DR. MUSTARD: And in that work, the fibers are very carefully separated out so that they have absolute control of the length and diameter in terms of what they are administering to the animals, or are there some estimates in that as well?

THE WITNESS: There would be estimates, I am afraid. It is not possible to get single length fibers of these dimensions by any techniques that I am aware of.

DR. MUSTARD: Did they quantitate the fibers they are administering, using the sophisticated measurement devices available when they did these experiments?

THE WITNESS: I can't answer that question.

DR. MUSTARD: But it wasn't based on optical measurement estimates? They did use electron microscopy to calibrate the fibers, did they not?

THE WITNESS: Again, I can't answer.

MR. LASKIN: Just one final questions on these percentage distributions, while I think of it. Since you indicated that even if a fiber is greater than five microns in length, if it is below a certain diameter we won't be measuring it on the optical microscope, or we won't be seeing it, how many of those fibers in a normal distribution might we be missing? In other words, how many fibers greater than five microns in length are we actually measuring in a workplace setting?

THE WITNESS: From the measurements we have made, we could see perhaps...this all depends on the size distribution...we have seen numbers, ratios there from four times the number to maybe twenty-five or fifty times the number.

MR. LASKIN: That you are not...?

THE WITNESS: That we are not measuring.

MR. LASKIN: On the optical microscope.

DR. UFFEN: Perhaps we could come back to this one later on. I don't want to interrupt your train, but one little point I would like to clarify.

It's labelled hypothesis. To what extent is it hypothesis and to what extent is it based on observation, and would the observations be on animals or humans?

THE WITNESS: I think maybe really the paper should be reviewed at this point, but the Pott's statements are that it would be somewhat illogical to assume that a fiber was biologically active at five micrometers and not biologically active at four point five micrometers in length, and that it is likely to be a continuous relationship rather than a step function. He has then taken what observations he has from the animal work, and extrapolated. This is very much a hypothesis. Those curves are not based on physical measurements all the way down.

DR. UFFEN: Can you point out something which

DR. UFFEN: (cont'd.) to me catches my eye, and it may not have with others? Two of the scales are logarithmic and one of them is linear. The index of carcinogenesis is a linear indexing. Is it arbitrary or is it not even linear?

THE WITNESS: I can't comment on that.

DR. UFFEN: Oh. It's worse than I thought then. Not worse, more complicated than I thought.

See, if you used linear scales, those curves would rise very, very rapidly, wouldn't they? There is a two by two by two by two multiplication?

THE WITNESS: Yes.

DR. UFFEN: So this graph could give a person a misleading idea of the relative carcinogenesis if you don't understand the scales?

THE WITNESS: Yes, you are quite right. The reason why he will have done them logarithmically on the two scales there will be that we are dealing with a logarithmic length distribution, and most of the data in this sphere is in fact plotted on logarithmic scales.

DR. UFFEN: But that index could also be logarithmic then?

THE WITNESS: It may very well be.

DR. UFFEN: Maybe we should ask a little bit more about it then.

THE WITNESS: Yes.

MR. LASKIN: I suppose for the record we should identify that slide as being figure one in tab nineteen of exhibit twenty-seven.

Sorry, Dr. Chatfield.

THE WITNESS: Basically, if we were to accept what Pott has said in his paper, we should be measuring all fiber diameters between about point zero three and three

THE WITNESS: (cont'd.) micrometers in diameter, and all fiber lengths perhaps down to about one micrometer, so that we take in the overall volume of that curve.

The point has already been made that although we have a declining carcinogenicity factor in those curves below about five micrometers, it's still a significant number, and the size distribution in fact may mean that the overall effect of small fibers may be in fact larger than those from the longer fibers, because there are fewer of them.

The basic reason for introducing these curves is that the data summarized by Pott don't appear to support the concept of excluding the small fibers from measurement.

Then we come onto measurement criteria. The definition of a fiber has always been, for the last twenty or thirty years, something of three-to-one aspect ratio or greater. That definition came about quite by accident, someone asking how do we define a fiber, how do we discriminate from a particle. Three-to-one is a convenient dimension at which we can say, well, this is beginning to get elongated. It doesn't have any biological or mineralogical significance at all.

From Timbrell's data we can say that the respirable fibers should be considered as one of maximum diameter of about three point five micrometers, and of any length.

The question of relative toxicity between species seems to be, at the moment, unsettled, and so we are not able to say whether we really need to identify the fibers during the measurement. It has been suggested at times that the use of a five-to-one or a ten-to-one aspect ratio definition might make the analyses somewhat easier and improve the reproducibility of fiber counting. Now, if you can look at...the next slide, please... this will indicate the kind of problems we are running into.

I don't think we would regard those as nonfibrous. Everything there is long and thin and no one would have any

THE WITNESS: (cont'd.) difficulty in defining those as fibers.

The next slide.

This is...that was chrysotile asbestos, the previous one. This one is UICC amosite. Now you see at this point on the electron microscope scale, these are fairly high magnification pictures, we are getting to be rather blocky, and the three-to-one aspect ratio will include the majority of those features, but the ten-to-one aspect ratio will begin to exclude rather a lot of them. We know that this material is UICC amosite.

If we go to the next slide, this material is a tremolite. It's an optic tremolite which appeared in the laboratory, and you'll see there a three-to-one aspect ratio begins to include things which we really wouldn't want to call fibers. The ten-to-one would exclude virtually everything in that field apart from the long thing going through the middle.

So we have here materials which are commonly considered to be asbestiform, or asbestos, and on the electron microscope scale, at least, we have things which we, at ten-to-one aspect ratio, would eliminate.

There seems to be little justification to increase the aspect ratio definition unless someone could demonstrate that fibers of lower aspect ratios are innocuous, and just to yield a more reproducible result doesn't seem to be a useful criterion because we may not be measuring the right things if we change it.

MR. LASKIN: When you say a more reproducible result, do you mean generally a more accurate count?

THE WITNESS: Yes. I mean two different operators working on the same sample would be able to recognize the ten-to-one aspect ratio fibers more reproducibly. In other words, they would always agree on the fact that these were the fibers they had counted, whereas it gets much more difficult at the lower aspect ratios.

MR. LASKIN: The counter argument is that we still don't know what the health hazards may be of aspect ratios between three-to-one on the one side, and ten-to-one on the other?

THE WITNESS: That's correct.

DR. DUPRE: Dr. Chatfield, could I just take you back to your statement about the question of relative toxicity between different asbestos species is unsettled, and indeed so it seems to be.

But you then go on to say, in the paper, "And so the requirement for identification of the species during fiber counts is also uncertain."

I wasn't quite sure I followed that because since in a number of jurisdictions, rightly or wrongly, standards have been set that differentiate among asbestos types, would it not be so that in those jurisdictions the requirement for identification of the species would indeed be certain?

THE WITNESS: You are quite correct.

DR. DUPRE: Whereas, of course, the general question remains unsettled?

THE WITNESS: That's quite correct.

DR. DUPRE: Thank you.

THE WITNESS: When we come to deal with ambient air, or inside-building atmospheres, then the ten-to-one aspect ratio would certainly simplify the electron microscope measurements, but for a number of reasons it is not appropriate for application to workplace samples. My justification for this is that something which is three-to-one aspect ratio optically, we have no guarantee that after inhalation it's not going to break down into a lot of thinner ones, which indeed do have high aspect ratios. This is a consequence of limitation of visibility, again.

Now, I would say that there is an urgent need for a precisely defined and reproducible analytical method for workplace air samples. If we are going to retain the existing

THE WITNESS: (cont'd.) fiber counting approach, then we have to improve it so that good interlaboratory comparisons can be made on a routine basis. I say on a routine basis because those comparisons that have normally been made have been made with full knowledge of the individuals concerned that this was a round-robin test, an interlaboratory comparison.

Using the NIOSH method as published, a recent ASTM group managed to find a factor of six between the high and low counts on the same filter, by experienced counters. This is a rather worrying situation, and this was done, again, when the analysts were well aware that this was an interlaboratory comparison.

What that's saying basically, is that one operator was able to see six times as many fibers on the filter as the lowest counter.

Unfortunately, any improvements in the analysis methods will change the value of the fiber concentration that we report. If fiber count obtained by any improved procedure is higher than that obtained by any earlier methods, this is going to be viewed by industry as a backdoor reduction of the legislated airborne concentrations. If the value is lower, it's going to be perceived as a relaxation of an existing standard.

We are faced with the problem that we are legislating by an index. This index is strongly dependent on the analytical method, the counting rules and the visual acuity of the individual and the performance of the microscope. Many of these things are not defined in current methods.

We are not dealing here with a precise and absolute measurement. We are making a measurement unrelated to any standards, which is subject to both instrumental variation and operator subjectivity.

There are a lot of improvements that can be made to the fiber count method, but they are going to change the values that are reported. The problem has to be addressed as to

THE WITNESS: (cont'd.) what action will be taken if we get an improved method which we want to introduce and it gives a value of fifteen fibers per mil, when in fact the old method gave an acceptable value of one point seven. This kind of thing can occur just by changing counting rules, and indeed at the international level there are such discussions already taking place about changing counting rules in the optical microscopy method. This is going to change the answer.

MR. LASKIN: Could you give us an example of that? Could you give us an example of how a change in the counting rules will change the count?

THE WITNESS: Well, for example, the British at the moment wish to count aggregates as anything up to eight fibers. In other words, we have, say, an aggregate appears on a microscope which we are not able to count. It is a complicated structure. We recognize that it is a complicated structure. One set of counting rules will say disregard that filter view and move on to another filter view which is easier.

Now, if we do this it biases the result to a low number.

The British wish to count that up to eight fibers. Now if they count it as up to eight fibers, what will happen is an industry like the asbestos cement industry will have a lot of aggregates within the material, and instead of disregarding these features altogether we are then in a situation where we count them as up to eight each. So we could find that the level previously considered acceptable would suddenly be multiplied by eight.

So a mere change of procedure can change the number that we are getting out of this measurement.

MR. LASKIN: On that particular example that you gave us, does Ontario have a method of treating aggregates at the present time?

THE WITNESS: I believe the method specifies 'move

THE WITNESS: (cont'd.) on to another field of view'.

The NIOSH method specifies that, and the Asbestos International Association method as published also states, move on to another field of view if one-eighth of the field is covered by an aggregate and you can't understand it.

But on the other hand, it does specify that the occurrences should be recorded. But recording of the occurrence doesn't introduce it into the numerical result.

DR. UFFEN: Could I ask a related question? I'm not sure whether it's in the paper you've just brought in this morning, which is an update, but it was in the one that you presented to us earlier in the year, and it's tab eighteen on page six.

You referred to the Asbestos International Association, a technique recently published by the AIA, using the different mounting. To what extent has that new AIA procedure been implemented, and does that distort the historical data?

THE WITNESS: That technique has not been generally implemented as yet. It is forming the basis of discussions at the International Standards Organization level. That is forming the basis of the method to be adopted.

The technique for mounting...the NIOSH method uses a mixture of two organics...I think it's diethyloxylate and dimethylthilate...to mount the filter, to render it transparent. It has to be transparent to look at it optically. This technique, therefore, immerses the fibers in a refractive index of roughly the same as the fiber itself. In other words, the fiber and the mounting medium are very close in refractive index, and that is the reason why we have to go to phase contrast, because without it we cannot see the fibers.

The AIA method uses a different approach. Acetone vapor is blown onto the filter and the structure of the filter

THE WITNESS: (cont'd.) collapses because it is rather like a sponge texture. The acetone vapor dissolves the filter medium and it collapses to a continuous film of plastic, which is transparent.

A drop of glycerol triacetate is added, and then the cover slip is put on the top of the slide and the whole thing then is a permanent mount. Unlike the NIOSH procedure, this slide can go into storage for recounting.

In general, the refractive index of that medium is different to that used in the NIOSH procedure. It does lead to an increase in fiber visibility. You can see fibers more efficiently in the AIA method, and the overall result of that is that it gives...I believe it has been measured, but I think it is of the order of twenty percent increase in fiber count.

DR. UFFEN: Would you say, though, that in the future it would be a preferred way to do it because you can keep the specimen and have a look at it again sometime and compare it with somebody else's?

THE WITNESS: I think as optical method go it is the best we have at the moment.

DR. UFFEN: Are there likely to be any better ones in sight, you know, in the next five or ten years?

THE WITNESS: I think I could talk on that later on, but there are methods on the horizon which may be more reliable.

DR. UFFEN: So we now have identified two ways in which the measurement...regulation based on a measurement technique could change significantly if the technique is changed by international agreement?

THE WITNESS: Yes.

DR. UFFEN: Are there any others?

THE WITNESS: Well, of course, we have discussed the counting rule problem, and of course then there is change of aspect ratio. These are problem of definition and they all change

THE WITNESS: (cont'd.) the number that comes out of the measurement.

As I was saying, the problem here is we are legislating on the basis of an index which is sensitive to the actual methodologies in use, and I would point out that in view of the factors of six and other studies that have indicated the procedures have been improving over the years, even though we are now still getting factors of six between operators, they have been improving. Any correlation with epidemiology would have to be looked at with some caution because we don't have accurate measurements of fiber concentrations.

The fundamental limitation of visibility that I was talking about is imposed by the wavelength of light, and we have discussed the point two micrometer diameter limitation. There are, in fact, no standards generally available for microscopists to test the performance of their equipment. Current microscopes which are marketed are not optimized with this particular measurement.

In the AIA method in particular, they make very specific recommendations regarding the absorption of the faceplate in the microscope itself to optimize the contrast of small features, and all these things were left uncontrolled in other methods.

Now, if we could go to the next slide, please?

Just to bring the thing into focus...oh, sorry, I had forgotten that one. This is the interlab comparison using the NIOSH method which I referred to. Counts were made by eighteen experienced counters and we have four different asbestos operations. You will see that the mean value, generally, is one fiber per millilitre, or thereabouts, and the lowest and highest values reported by those eighteen operators are listed. You can see there is a substantial variation there, the worst one being the third column...a ratio between the high and low of six point two.

The consequences of this are, of course, that if that was a single measurement the point three three would most

THE WITNESS: (cont'd.) definitely be a good number, and the two point zero four would be above the current legislated airborne standard.

Next slide, please.

Just to emphasize the limit of optical visibility, here we have an electron micrograph of a single chrysotile fibril. That is the ultimate fibril size of chrysotile. It's about point zero four micrometers in diameter, and the two circles represent... first of all, the small circle is the point two micrometer diameter circle representing the limit of optical visibility of a good research optical microscope. The larger one represents the point four micrometer, which is the situation that may exist in many microscopes. So we are somewhere between the two.

MR. LASKIN: But that's the electron microscope, what you are showing us there?

THE WITNESS: I'm showing an electron micrograph with a circle representing the minimum diameters that you would be able to see on an optical microscope...sorry...that's right, on an optical microscope. Yes, you are right.

MR. LASKIN: Just one question on the last slide where you showed the interlaboratory differences. Were those differences completely as a result of the different judgements applied by the different persons who looked at the membrane filter? They weren't differences in counting technique or anything else?

THE WITNESS: They were using the NIOSH method as written down. Beckett and Walton did publish a number of reasons for disagreement between operators, and they came to the conclusion a long time ago that such discrepancies could only be resolved by having the different operators looking at the same field of view in a microscope and discussing the situation live. It was not possible to produce a method written down which one operator and another operator would get the same answer consistently.

MR. LASKIN: So those different answers were because different operators viewed the same filter, the same slide, differently?

THE WITNESS: It may have been different judgement, different microscopes, minor misalignments of microscopes. One doesn't necessarily expect that an operator fully understands the equipment and he may come to the instrument to do a count and find that afterwards it was misaligned.

You don't need very much misalignment, of course, to cause a change of fiber visibility. It is very critically dependent on accurate alignment of the microscope.

DR. UFFEN: And even the depth of focus.

THE WITNESS: Oh, that is a point that I didn't mention, the fact that Beckett and Walton also reported that the ...I think it was Beckett in that field, I beg your pardon... reported that one of the failures of operators in getting the low result was their failure to rack the focus up and down so that they were looking throughout the depth of the filter where the deposit is, and therefore missing fibers because they happened to go in and out of a roughly one micrometer depth of field.

You can go on to the next slide, please.

In any airborne size distribution we have...where are we here...oh, yes. Just to make the point again of visibility, we have in the upper figure a phase contrast micrograph as seen of an airborne asbestos distribution on a clear medical filter. This is prepared by the Asbestos International Association method.

The arrows on the lower photograph point to fibers longer than five micrometers, which are visible in a scanning electron microscope image, which do not appear in the phase contrast micrograph. Now I will agree that we are not in a position when we take a photograph in phase contrast, to do the racking up and down of focus. So some of those may be found by an

THE WITNESS: (cont'd.) operator, but nevertheless there are features, very many of them, which do not appear in phase contrast image.

The next slide, please.

I have already dealt with this in some detail earlier, but this is not strictly...we should not interpret the axes of this graph rigidly, but that is what a size distribution of fibers would look like...a length distribution showing the number of fibers on the vertical axis and the length of the fibers along the horizontal axis. It is a logarithmic normal distribution of length, and so the distribtion is skewed.

If we then look at the continuous line, that is intended to represent fibers of all sizes, all widths and all lengths.

The dotted line represents, of those fibers, those which we can see optically on account of their diameters being large enough. So the only part of that distribution we actually measure by current techniques is the portion which is shaded white, above the five micrometer mark on the horizontal axis.

MR. LASKIN: What's the reason that we don't measure all of the rest of the fibers that we can see on the optical microscope?

THE WITNESS: Well, first of all, the judgement of diameter is rather difficult when you are working as close to the optical visibility as this. What we have, if we have...say, if we take a one micrometer fiber length, which is one reason why I have cut that distribution at one micrometer...if we take a one micrometer fiber length, a three-to-one aspect ratio would mean that we had roughly the optical visibility of about point three micrometers in diameter, so we are looking at an interference fringe. We are not really looking at a width which we can measure, and I think subjectively you cannot discriminate fibers

THE WITNESS: (cont'd.) from other features in that area.

So the five micrometer limit is a reasonable, practical cutoff from the measurement side, from the actual point of measurement.

What we are intending to show there as well is, because we are measuring such a small portion of that graph, of the total fibers, the total fibers would, of course, be represented by the area under the continuous curve. Because we are measuring such a small proportion of that, when we come to vary the number that we see...in other words, if the number longer than five micrometers changes...we really have no idea what has happened to that continuous curve. It is not a reliable indicator of what is going on below there.

If we can go to the next slide, please?

One of the other complications has been that with the gradual improvement in atmospheres in workplaces as a result of the introduction of engineering controls, there will have been a change in size distribution, both in length and in diameter. The overall effect of that will have been to have shifted from the broken line to the continuous line, and once again we are just measuring the portion of the curve above the five micrometer mark. In the case of the continuous line, we are measuring the solid shaded area only. The hatched area there is intended to indicate the total number of fibers longer than five micrometers, as opposed to those we see optically.

So once again we may have, if you look at that you would say, okay, we are going to have a big change in the numbers reported longer than five micrometers as we shifted that size distribution, but the area under those curves is not really changed very significantly. So in terms of the total fibers, a reduction of long fibers may not be a good indicator of what is going on.

THE WITNESS: (cont'd.) Now, we can make one or two comments at this point on the fiber counting rules which we have already dealt with briefly. The rules for counting fibers were established in a method so that specific geometrical arrangements of fibers are counted by different analysts in the same manner. This is not to say that any defined manner has any biological significance. It is just a means of improving the interanalyst reproducibility.

Counting of single isolated fibers doesn't give any problem, usually. It's the bundles, random aggregates and fibers associated with other materials where there is controversy about what to do about it.

The common rule is to disregard the fields of view which are overloaded with debris. The conventions adopted for complex aggregates nowadays range from disregarding the field of view, as I said before, to counting each aggregate as perhaps up to eight fibers.

The asbestos cement industry would find that if we started to do that, to count eight fibers for each aggregate, it would increase the numbers reported in that industry.

It is obviously important to consider what we should do with these things. The large aggregate shown in the next slide is an electron...a scanning electron micrograph again.

You see the magnification marker there indicates that the majority of the fibers in that aggregate are longer than five micrometers. They are at the limits of optical visibility individually, so optically that thing would be perceived as a roundish-looking feature with the odd fiber sticking out of it, at the limits of visibility.

So one might say, well, this is just a piece of debris with a fiber stuck to it, we are going to ignore it.

Alternatively, as you can see, there are probably hundreds of fibers in that. It is also in the size range where it

THE WITNESS: (cont'd.) could be considered to be respirable, and one can only question what we should do with features of that kind.

First of all, optically we can't see them, but even when we can see them in the electron microscope, what do we do about that kind of feature? It contains a lot of fibers.

Go on to the next section - detection limits of phase contrast methods. Detection limit is about point one fiber per millilitre. This has been published in a number of areas. The AIA analytical method specifies that it is generally agreed that point one fibers, that the limit of detection lies somewhere between point one and point five fibers per millilitre.

If we assume that point one is the best we are going to get, then all values...we must not consider these values as single numbers. All of these things have a confidence interval around them.

What this means is that it's really questionable whether point one and point two can be shown to be statistically different using the current methods. We have filter backgrounds to take account of, which further complicate the issue, but that has some consequences for enforcement of a point two fiber per millilitre standard for crocidolite. One is not able to reliably say that the maximum is different from your detection level. We have a problem. If you run an ASA poll in places where you know there is no asbestos, then you will get numbers in the vicinity of point one cropping up very frequently.

DR. UFFEN: Could I ask a question here? I think it begins...not in your today's paper, but it was in a similar section in your previous paper, tab eighteen, page nine. You made a statement which has an expression in it that I am not sure whether I understand. It was, "It's not known whether the fibers observed in the optical microscope are the ones

DR. UFFEN: (cont'd.) "responsible for the
health effects, and it may indeed turn out that
the index of exposure is not related to this
measurement at all".

Do you remember that statement? What is the index of exposure? Is that something that I should have known about by now?

THE WITNESS: No.

DR. UFFEN: Okay.

THE WITNESS: I don't think I'll define anything, but I would personally think of an index of exposure as something which is related to a health effect. In other words, a number that I can use to say this number, if it's high, there is a high potential for giving health effects; this number if it's low means there is not much of a health effect.

But unfortunately...

DR. UFFEN: Is there an index being used by other people?

THE WITNESS: No. I would think we need an index of this kind.

What I am saying there is that if I measure the number of fibers longer than five micrometers optically, and I measure the number of fibers longer than ten micrometers optically, I don't necessarily find a relation between the two. I don't find them going parallel.

The problem here is, of course, which one should we take? We have selected something rather arbitrarily at five micrometers, when in fact ten micrometers may give a number which is more closely related to the health effects.

This is just not known.

DR. UFFEN: Is it possible to define an index of exposure in such a way as to get international agreement or general agreement?

THE WITNESS: I think one would have to speak to medical people on that, I suppose.

Purely from the measurement side, we are not able basically to say...if I have, if I put a cut in a size distribution of five micrometers and elect to measure only everything above that length, then I am not sure how steeply that size distribution is behaving at that point. I may very well make a measurement of, say, essentially zero larger than ten micrometers, but have ten fibers, say, longer than five.

Now in other words, the distribution may have suffered a cutoff at that point. So by measuring at that point, I would say there is no asbestos. But by measuring at five micrometers, I would say there is asbestos.

What I am saying is, the two measurements that I make with those two different cutoffs, are not necessarily related.

DR. UFFEN: If we did try to have an index of exposure, would it also have to take into account where in the lungs the exposure was supposed to have taken place? Would it have to be both the measurement of the particle and where it came from?

THE WITNESS: It is certainly going to be related to fiber size. I think this is one of the problems that has to be faced...should we be having the indices of exposure related to the total distribution, or should we be having them related just to specific-sized cut?

DR. UFFEN: Exposure to me is a target and a productile, okay? And we are talking at the moment about the productile. Without a target, there is no exposure, so should we also be talking about the target before we could have an index of exposure?

THE WITNESS: Basically, we need the medical people to say what the size...what the fiber dimensions of interest

THE WITNESS: (cont'd.) are, those that are going to get to that target.

If we can go on to the section two point six in this document, the proposed regulations in Ontario specify different standards for chrysotile, amosite and crocidolite. We need guidance in that methodology on what to do about the mixed-exposure situation. For various reasons, these minerals are used in a mixed form and if an intermediate standard is used...supposing we say, okay, we are using ten percent crocidolite and ninety percent chrysotile in this plant, let us use an intermediate level of standard, then that does not create a very satisfactory situation for the person who is unloading the crocidolite. He is exposed totally to crocidolite. So if we want to control him at point two, if we want to control somebody else who is only handling chrysotile at one fiber per mil, we have a problem in the intermediate situation because we are using a nonspecific analytical method. There is no identification involved, so we count fibers.

MR. LASKIN: So what you are saying is, if you've got a work environment where you are using more than one fiber type, and you've got differing standards for those different fibers, you are not going to be able to use the optical microscope to assess whether there has been compliance with those different standards? Is that what you are suggesting?

THE WITNESS: Not unless you use the most severe standard.

MR. LASKIN: I see. In other words, somebody is using chrysotile in a particular plant, if you apply the Ontario proposals one would have to meet the crocidolite standard, but you won't know from the optical microscope which fiber it is he has been exposed to? Which fiber type?

THE WITNESS: What I'm saying basically is, if someone introduces crocidolite into the plant, the only way of control, using the existing method, would be to control the entire

THE WITNESS: (cont'd.) plant at point two.

MR. LASKIN: At the most stringent standard?

THE WITNESS: Yes.

MR. LASKIN: Because of the inability of the optical microscope to distinguish between fiber types?

THE WITNESS: Yes.

DR. DUPRE: I presume that your message there also suggests that simply they're technologically determined by the optical microscope, if you go to another type of instrument?

THE WITNESS: Oh, technically it is certainly possible to discriminate.

DR. DUPRE: That statement that you made does not imply...?

THE WITNESS: No. If you go to another instrument then fine, you can do something about it. But as the proposals stand at the moment, if you have crocidolite coming in at one door and chrysotile in at another door, then you have a whole spectrum of different exposures - exposures to the different minerals, and it is difficult to know exactly how to apply the existing standards, because you are wanting to control at point two for crocidolite and one fiber per millilitre for chrysotile.

MR. LASKIN: Is the other method that you are suggesting here that the optical microscope isn't sensitive enough to control in any meaningful way at point two?

THE WITNESS: Yes.

MR. LASKIN: You are suggesting that?

THE WITNESS: In the AIA method it does in fact specify that it is not possible to improve on this detection level by filtering more air.

MR. LASKIN: Is it, in your judgement, your professional judgement, is it sensitive enough to measure in a meaningful way at one, at a standard of one?

THE WITNESS: At a standard of one it is ten

THE WITNESS: (cont'd.) times the standard deviation that one normally encounters. It is a meaningful measurement at one.

DR. DUPRE: Is it fair to say that if you just constantly use an electron microscope, at this point what you say in paragraph two point six does not apply? Everything that is stated in paragraph two point six is conditioned by the assumption that optical microscopy...?

THE WITNESS: Yes, certainly. Yes.

MR. LASKIN: Dr. Chatfield, I don't want to take you out of your paper any more than I already have, but following up on what the Chairman has asked, will you at some stage discuss with us today whether there are any options in the workplace, in your judgement, having dealt with the subject, that are practical or feasible?

THE WITNESS: Yes, I will do that later on. Actually that could be left until after lunch. I have some slides which will demonstrate what we are talking about.

The other thing of concern to me, because we've come into this problem on a number of occasions, is that asbestos regulations based on phase contrast microscopy, if they are applied to an industry or occupational group where the materials are not necessarily asbestos, they are something else, supposing I say I go into a plant where vermiculite is being used...there is a plant in Rexdale which is doing just this...and I come in and I take a phase contrast optical count because someone is worried that there is fibers, asbestos fibers, in the air in that plant, we get results. We will get fiber count results out of that method, which they are all counted as asbestos and there is absolutely no way that this phase contrast method is capable of handling this situation.

If we can go to the next slide, please?

That is a phase contrast micrograph of the material

THE WITNESS: (cont'd.) found in a vermiculite-using operation. As you can see, there would be no problem in finding a number of fibers in that field of view. And indeed, if we go to the next slide which shows some of the actual numerical data produced, you see that we have personal and static samplers run in this plant, and everything counted by the appropriate NIOSH method. You see we have fiber concentrations varying from point six, roughly, point five nine, down to point one.

Now, this is a fair proportion of the standard of one fiber per mil that is being suggested, and electron microscopically there is, in fact, no asbestos in this material. If asbestos regulations are applied to all of these peripheral industries, such as the vermiculite, talc, iron mines and such, then numbers come out. They are not asbestos fibers necessarily, but they are numbers, and the difficult here is that it is a totally inappropriate technique outside of the asbestos industry.

In the asbestos industry we are assuming that every fiber that we find is asbestos, and provided the engineering controls keep it below some predefined limit, then everyone is reasonably happy.

Here we have a situation where you need to demonstrate that asbestos is present in the first place, and the asbestos regulations do not require this. A phase contrast fiber count is made in an area where asbestos is suspected to be present.

Now, I would add one other area here, would be the gypsum industry. If you were to go into a gypsum plant and you had any suspicion that asbestos was present, you could run an air sample and you would get very large fiber counts, because the gypsum is often present as assicular crystals with aspect ratios greater than ten-to-one.

If we could go to the next slide, please?

The next slide shows the actual electron microscope results we obtained on the same filters from the vermiculite

THE WITNESS: (cont'd.) operation, and they were indeed below our levels of detection, longer than five micrometer fibers were below level of detection, and indeed everything else was very close to our level of detection.

Mineralogically we have demonstrated that no asbestos is present in this particular material, and yet we are getting high numbers by phase contrast.

The basic problem here is that the asbestos regulations must only be...workplace asbestos methods must only really be applied to those places where asbestos is present in very large amounts. Other occupational groups where the potential exposure to asbestos is limited to its mere presence in the building as still part of the building structure, or alternatively has been used in there at some time, you should not be subject to the same standards as an asbestos worker whose health is under surveillance. The analytical method we have here is totally inappropriate for this situation, and the occupational levels applied of two fibers or point two, whatever we care to use here depending on the type of material, is an inappropriate exposure for someone other than an asbestos worker.

Now, at this point you get into the rather difficult topic which I spoke about just before last Christmas, of the definition of asbestos. If you are presented with an air sample and nothing else, then it is very difficult to define asbestos on the basis of the particles you find.

In the talc industry just because we find tremolite or anthophyllite in the sample doesn't mean to say that asbestos fibers are present. The mineralogical material may not be the fibrous habit, it may not be the fibrous form. And so a simple x-ray diffraction measurement in these cases doesn't show that the material is asbestos.

There are two principal aspects here. Firstly, the application of this phase contrast method, because it's

THE WITNESS: (cont'd.) convenient and inexpensive, should be restricted to the well-characterized situations which we find in the asbestos industry. The other question we have to address is how we are going to define asbestos in industries where mineral fragments, assicular crystals and perhaps even asbestos fibers in some cases, occur in the material being mined. There is also then the question of definition when we are reporting the presence of the various forms in consumer products. What concentration of asbestos can we accept in cosmetic talc, what concentration of asbestos can we accept in building insulation? We are never able to demonstrate zero, so we end up having to say some number or other.

Obviously, one would treat talcum powder as something rather different to building to insulation. Talcum powder is applied to the person, the building insulation is very largely applied and then sealed up in some way.

Can we have the next slide, please?

Just on the electron microscope, I'll just point out that that is a high-magnification micrograph of a single chrysotile fiber, and you note the tubular structure of that.

If you go to the next slide, there is a problem of definition when you come across something like that. It's the same diameter, it has some evidence of a tubular structure. That is the material which you will find in a vermiculite. It is a vermiculite plate which is rolled up. It is not asbestos by normal definitions, but we have a grey area here.

If we go to ambient atmospheres, the airborne fiber concentrations are generally a lot lower than they are in the asbestos plant. The character of the airborne material is also different. The fibers are present, but they are not all asbestos. In outside atmospheres in particular, chrysotile asbestos is usually present as small bundles, very small bundles, or individual fibrils of the kind I've just shown, which are

THE WITNESS: (cont'd.) all below the detection capability of optical microscopy.

This observation applies as well to the inside of buildings where asbestos is known to be present as building insulation, and accordingly most agencies, including the EPA, the Germans and the Swiss, have specified electron microscopy for the analysis of ambient samples of all kinds...ambient samples being outside atmosphere or water samples.

Now, since the biological effects of the low-level exposures are not known, we need some basis of comparison for ambient air analyses. The pressure is to demonstrate that a building atmosphere or an outside atmosphere is satisfactory. I can't define the word satisfactory for you, but when an analysis is being done, it is being done because someone wants to demonstrate that either asbestos is not present or it's below some standard or other.

The only standard we have at the moment is the Ontario Ministry of the Environment guideline which stands at point zero four fibers per millilitre, and that's fibers longer than five micrometers measured by electron microscopy.

At the March, 1981, meeting in Luxembourg, of the International Standards Organization working group...and I'm the convenor of this particular working group...it became evident that this level is too high for acceptance by many countries. Detection levels in Germany and Switzerland, being talked about, are one fiber per litre...of any length.

Now, if we are going to compare, and indeed in Germany we are also talking about detection levels of point one fiber per litre, again a fiber of any length, by comparison the Ontario guideline of forty fibers per litre longer than five micrometers in the normal size distribution encountered would correspond to a concentration of two thousand fibers per litre, if we are considering all lengths of fibers.

Now we have been working to detection levels of

THE WITNESS: (cont'd.) one fiber per litre inside buildings, and there is no particular difficulty in meeting this criterion in a clean atmosphere. But in the urban atmosphere if I was to take a sample outside in the city of Toronto, we would have difficulties in some cases in meeting detection levels of the Ontario guidelines - forty fibers per litre longer than five micrometers. The reason is the total suspended particulate.

In order to detect one fiber per litre in the outside atmosphere, one may have as many as several milligrams of total solids on the filter, amongst which you are trying to find a very few asbestos fibers.

Now we have agreed to leave this problem for the time being whilst we look at possible analytical procedures which will allow detection levels of one fiber per litre in urban atmospheres. In other words, that problem has been put in abeyance for about twelve months.

It seems clear, though, that other countries may establish ambient air standards below that which we already have as a guideline in Ontario. Since the precise analytical method that we are going to use here depends on the detection level that we are trying to work to, there is a need to define an actual ambient standard that we can work to. We need to compare.

We cannot comment on health effects, and therefore we have to work to a number which somebody is going to give us. We have to say it's better than the government standard. That's the only way we can deal with the situation.

MR. LASKIN: Given that you are using the transmission electron microscope and presumably measure fibers of any size, can you tell us what the thinking is behind setting the ambient air guideline in terms of only fibers greater than five microns in length? That is, the index on the optical microscope?

THE WITNESS: I'm not going to make anything up,

THE WITNESS: (cont'd.) but if you take the...I believe it was derived along the following lines: two fibers per millilitre for chrysotile asbestos extrapolated or divided by the total number of hours of exposure. In other words, an eight hour working day versus twenty-four hours per day for the full week.

In addition, there was then the question of exposure for the full lifetime rather than the working lifetime, so we reduced the thing by a factor of whatever for the seventy years total versus the working lifetime of perhaps forty years.

We then have a factor of ten or thereabouts thrown in for good luck, and to discriminate between the population at large and the asbestos worker.

It's a common thing to have occupational groups permitted to have larger exposures than the general population.

MR. LASKIN: But leaving aside whatever the number is, do I take it from this little discussion here that most countries, if they have gone to fiber counts in the environment, have measured all fibers and have not used the index that is used in the workplace with the optical microscope?

THE WITNESS: As far as I know, Ontario is the only one which has done this particular, gone this particular route of specifying longer than five micrometers, and I personally don't see any particular justification for it.

DR. UFFEN: I think we are going to mark the transcript right there. It seems if things have unfolded as counsel has indicated in the question, we are finding that fundamental difference between the specifications and the ability to measure or interpret, and yet they seem to persist in the guidelines or regulations.

The question of a standard for ambient levels, this has been raised recently with us too, would you expect that there could be a single standard? If you are working out

DR. UFFEN: (cont'd.) or your laboratory is, and it's relatively clean, and if you were working beside the Nanticoke generating plant at Burns Cove, it would seem to me that the background could be quite drastically different. Or in northern Europe or in central North America.

Is there such a thing as a natural background free of manmade problems? Just those due to volcanic dust in the air and things like that? Is this being investigated?

THE WITNESS: There are some publications on natural backgrounds, and obviously that cropped up at the time when the building questions arose, the school buildings issue, in that our procedures at that time were that we are not in a position to make medical comment, but in order to say is there any contribution from a building insulation to the natural background, we have done a few measurements inside and outside of buildings, and generally we find fibers. There is absolutely no doubt that one does find a natural background.

But very largely the buildings have not in fact given any fibers above what we would expect to find outside. Now this would be against the work, or in contradiction to the work done by Sebastien in Paris, who has done an extended study in Paris inside buildings and outside, and he came to the conclusion that anything more than about...I believe he used the figure seven nanograms per cubic meter...was in fact a contribution, a real contribution from somewhere.

Seven he would encounter everywhere, or numbers up to seven he would encounter in many locations.

DR. UFFEN: Seven nanograms?

THE WITNESS: Nanograms per cubic meter.

DR. UFFEN: Per cubic meter. And we have to translate that into fibers somehow. Has he attempted to do that?

THE WITNESS: Yes. What we have to do here is

THE WITNESS: (cont'd.) determine how the measurement was made. If you encounter a nanogram per cubic meter figure, that has usually be derived by doing a fiber count numerically and then computation of a mass from the size distribution, assuming the density of the material. So, calculte the total volume of fibers and multiply it by the density. That's how most of the nanogram figures have been derived.

MR. LASKIN: So most of the nanogram measurements that we have seen, in your opinion, are not direct measurements of the mass or weight?

THE WITNESS: You would have to look at the individual papers, but very largely they will be computed masses.

DR. UFFEN: Not solely from fibers, from particles?

THE WITNESS: No, it would be computed mass of fibers. So in other words, you identify each fiber in turn and then measure its dimensions, its diameter and its length, and compute the volume. So you have in fact eliminated particulate. You've only accounted for the mass of fibers.

DR. UFFEN: I'm going back to something that you weren't here for, but we were talking about a little triangle of fibers per unit volume, particles per unit volume, and nanograms. There seem to be a possibility of two conversion factors whether you are converting from fibers to nanograms or vice versa, or from particles to nanograms or vice versa. Is that correct, that understanding?

THE WITNESS: Yes, it would be. But if we are measuring asbestos fibers and reporting those, then it would be the fiber conversion to nanograms that we would be dealing with.

DR. UFFEN: If somebody had been measuring particles, of which asbestos fibers were only a part, then their conversion to nanograms could be different again?

THE WITNESS: Yes.

DR. UFFEN: Unless they knew the relative amount of fiber to particle?

THE WITNESS: Well, of course, if you are going to do that, then you need to know the identity of every particle you do it with because you have to use a density.

DR. UFFEN: So then the nanogram measurement, anything recorded in nanograms, requires a great deal of interpretation?

THE WITNESS: Yes.

DR. UFFEN: Thanks.

MR. LASKIN: What is the utility of a nanogram measure? Why are measurements made in nanograms as opposed to fibers?

THE WITNESS: There is a school of thought that says that if in the analytical procedure it is sometimes necessary to, before preparing the final sample for counting, it is necessary to destroy or get rid of much of the other debris.

In other words, take an air sample, you may have a lot of organic debris, fibers of cellose, particles of pollen, and odd things of this kind, and this has to be...if you can get rid of that from the analysis, it makes the analysis much easier and you can work to better detection levels. So the procedure is to ash the filter, and then to redisburse the ash ultrasonically.

Now there is a school of thought that says that that disturbs the size distribution, and therefore since we now no longer know what the original sizes were, it is no use reporting a fiber count. But even if we have broken them down, the mass will have remained the same. They may be different lengths, but the material is still there, still identifiable, and we can count the fibers and then we can compute the mass, even if we had to assume that our particles are broken down.

So the nanogram figure is introduced at that point by saying well, we are not able to measure fiber numbers, all

THE WITNESS: (cont'd.) we can do is really to report a mass, to be reliable.

MR. LASKIN: If one were going to set some level or standard in the environment, leaving aside whatever it should be, is it your professional opinion that the standard should be set in terms of fiber count or in terms of a weight or mass measurement?

THE WITNESS: Since the best information we have at the moment is that fiber numbers seem to be the biologically important criterion to have, I would say a number count, provided we have the analytical methods to do this.

If we can go on to analytical criteria for ambient air samples, and this is in fact a continuation of what we were just talking about, the mass concentrations and numerical concentrations, and also identification criteria have never been specified in any of the methods that have been published, and how to handle the bundles and aggregates again, these problems are at least as serious as they are in the phase contrast method, but on the other hand we can at least see them.

If you look at figures eight and nine, please, which are on the same slide, this is...these are photographs on electron micrographs of aggregates of material from a serpentine deposit. I don't know where the samples were collected, but the problem was, basically, of a rock-crushing operation associated with placing material on graded roads.

We have here the upper picture, what is seen on an electron microscope. Now, we have a definition problem here. We really don't know what to do with that thing. It is almost certainly respirable in size, it is of the order of size to be respirable, and we have a lot of fibers sticking out of it which we can identify as chrysotile asbestos. Those two little spikes sticking out we can identify.

Then comes the definition problem - what do we do with that in the way of incorporating it into our measurement in

THE WITNESS: (cont'd.) actual number.

A scanning micrograph, the lower picture, shows that if you look at it in the SEM so that you see the overall morphology of the particle, you can see that a large amount of that material is in fact fibrous.

Now the question we have to answer, are we going to say, do we break that lot down ultrasonically and assume then that we are getting the worst situation in the measurement, or what are we going to do with it? Do we break it down or not?

This criterion for analytical methods is needed.

DR. MUSTARD: Can I ask you a question? Having listened to all of this, would I be right in concluding that the fiber count technology that has been applied to all the epidemiology that we've had, which is optical, suffers a very serious problem in that what they are counting as fibers are, in many of these things, there is a risk that these blobs are in there, in their counts, because I think you showed us earlier on that they can look like a fiber in the optical system? So that in effect we do not know what the health hazard is of this material in this form?

In other words, that if we are talking about fibers, we are talking about optical definition of fibers which includes conglomerates of material, and that the question to be raised is, is that stuff a real health risk as well in that form, and therefore has anybody done any animal experiments putting in exactly that material to see what happens, or are we left with a very important open-ended question that we simply do not know the answer for?

THE WITNESS: It's a very important open-ended question. That material would in fact be excluded from any optical fiber count.

DR. MUSTARD: But some of the innocent stuff in that form, you showed us one earlier on...

THE WITNESS: Oh, if it was elongated, then that thing would be called a single fiber according to some definition or other.

DR. MUSTARD: Now, these conglomerates, do you know if, for example, in the mining operations they get this kind of material in the system? You indicated that the cement operation tends to get this, and the textile area. Do you know anything about the frequency where this kind of stuff contaminates the counting system? Have you done any studies on that?

THE WITNESS: I don't know the frequency of it. Theoretically, of course, it can occur, and...because certainly chrysotile asbestos occurs in seams and during the crushing operation you will get fibers coming away with a large lump of this material attached.

Again, the work has probably not been done.

DR. MUSTARD: So that the meaning of so-called fiber counts in the different areas..if this hasn't been resolved... would have to be very, very carefully interpreted?

THE WITNESS: If it's going to be applied to an epidemiological study, certainly.

DR. DUPRE: Just pursuing Dr. Mustard's line there, I am beginning to wonder if what you are telling us here doesn't once again raise the serious question on these epidemiological studies of whether the dust particle counts should indeed have been converted to fiber counts. Because presumably if you've got the old particle count, if everything is aggregated in there as it is for these historical reconstructions, and of course there is some controversy always as to what your conversion factor is going to be, from dust to fibers, but what you tell us here to some degree shakes my confidence even further in what the conversion factors, if you want to change dust to fibers, might be.

DR. DUPRE: (cont'd.) Am I wrong to feel a little shaky?

THE WITNESS: No, you should feel shaky at this point.

May I make a point that that particular example there is not a commercial asbestos mining operation. That is a rock-crushing operation where that rock was being used for graded road construction. So that is not a commerical chrysotile operation at all.

MR. LASKIN: Is one of the other messages that you are trying to convey that if we are looking to set some kinds of standards in the future, it is not enough just to set a particular fiber level, you've got to put beside it specific counting rules, specific instrumentation and so on?

THE WITNESS: Yes. A methodology printed on its own without any definition of what you do with things like this, apart from ignoring them, really is open to every analyst's interpretation, and his own individual interpretation.

MR. LASKIN: Does that mean that even the epidemiological studies that are being done today may be producing very significantly different results simply because they've got different counting rules or different definitions or different instrumentation?

THE WITNESS: It may produce different results for a number of reasons. That is, there have been a lot of interlaboratory comparisons made in the last few years which probably has improved the method from what it was, say ten years ago. But it leaves me feeling worried when we are, at the moment, discussing whether or not we should count one of those things as eight fibers or ignore it altogether. The consequences on the number that comes out of the measurements can be enormous.

MR. LASKIN: Dr. Uffen?

DR. UFFEN: Another thing that we should draw from what you have just told us, that is I think new, is that with respect to the ambient situation, other countries are likely to use the...either transmission electron microscope or scanning electron microscope, and set standards very much more restrictive than Ontario guidelines, and that this may come about fairly soon? Shall be shortly established. Does that mean six months or six years or...?

THE WITNESS: I really don't know. The pressure is on in Germany. That's one of the only things I can say. The pressure is on to make measurements at this kind of level of sensitivity, and thereby is a question.

If international standards organizations get into the business of designing a methodology to detect, say, point one fiber per millilitre...sorry, point one fiber per litre, are we then encouraging the legislators to come in and say, okay, now we've got a method, let's legislate at that level? Or is it the other way around? By merely making available a method at this detection level, one may encourage legislation at an artificially low value. We don't know what value we should use. We wait to be told.

Of course too, no one has actually demanded this apart from the public.

DR. UFFEN: Is the International Association on whose committee you are chairman, is this a voluntary association in which Canada is a voluntary member? Or is it...?

THE WITNESS: ISO is an international organization based in Geneva, and the Standards Council of Canada is the Canadian member of that organization.

DR. UFFEN: There would be no legal obligation on Canada to accept the international standard, but there would be other pressures because we have been members of this, to accept...?

THE WITNESS: There is no legal requirement. The usual thing that happens is that countries do adopt the method with...sorry, in some cases there are minor modifications. It helps for intercountry comparability, and this sort of thing.

DR. DUPRE: The method, not the standard?

THE WITNESS: The method.

DR. UFFEN: What about the standards?

THE WITNESS: The Standards Organization would not set a standard...an actual airborne level.

DR. UFFEN: In our homes, as far as Ontario is concerned, in Canada, the routing might be that Canada might accept the method, and that Ontario might be in a position of either accepting or not accepting. We might have a little conundrum.

THE WITNESS: Certainly.

DR. UFFEN: Are you a member of the Canadian committee that would be working in the same area as the international one?

THE WITNESS: Yes.

DR. UFFEN: What federal agency would be involved? Is it the National Research Council or the Department of Health, or Energy, Mines and Resources?

THE WITNESS: The federal agencies that would be involved in this would be Health and Welfare Canada, and Energy, Mines and Resources, and the thrust for agreement between the EEC countries and Canada on methodologies of this type is going on under auspices of the Department of Industry, Trade and Commerce. There are meetings going on between a Canadian committee and EEC committee on this. I was present at that as well, which was in March of this year again.

The chairman of the particular group is Mr. George Reilly, of Energy, Mines and Resources.

DR. UFFEN: Is there someone on that committee

DR. UFFEN: (cont'd.) or in that group who represents the Province of Ontario's government agency?

THE WITNESS: On the...?

DR. UFFEN: You are from a nongovernmental agency.

THE WITNESS: This year this is Dr. Dave Leon from the Ministry of Labour.

Okay, can I go on to the next slide, please?

I would just comment here that the phase contrast fiber count method has continued to be inappropriately applied to environmental air samples. This technique is being used in building air sampling, and is recently being used in another location to do outside air sampling.

Just as an example, first of all we have the...we have said that the asbestos fibers in ambient atmospheres are all below the resolution limit of the optical microscope, so we are not going to see them anyway. The detection level of point one fiber per mil cannot be improved merely by pulling more air through the filter. If the fiber count is performed rigorously on a properly loaded filter, this detection limit does stop, it does stop at point one fiber per millilitre.

This slide that you see there was taken out of a building atmosphere in Toronto. It contains amosite and it contains gypsum. If you were to do a fiber count on that particular sample, there are enormous numbers of fibers longer than five micrometers. Only the three bright ones that you see in the middle there are in fact amosite, and I happen to know that because we put the same sample into a scanning microscope to find out.

The vast majority of those things are gypsum.

If we go to the next slide, this is a slide taken out of a building which had no asbestos at all. It did have mineral, wool and gypsum, and once again the darker fibers that you can see there are in fact gypsum. They are nothing to do with asbestos.

THE WITNESS: (cont'd.) The next one please.

This is a general building air sample where asbestos is known not to be present, and you'll see we have a number of things in that field of view which, if we were counting them, we would have to call fibers. They meet the criterion of having an aspect ratio greater than three-to-one, and so we have to count those.

Now, this really I present as some evidence that we should not be using this in ambient air. You always find things which you can count as fibers, in ambient air. I would say that results obtained by the use of phase contrast in ambient air samples or in building air samples...and I define buildings as a building of this nature where asbestos is not being manipulated... should be, we should just not accept measurements using this technique in these situations.

What I've said here is that there are a number of problems of analysis. It doesn't mean to say that there are not one or two things on the horizon, and I will in fact mention later on, when the opportunity comes up, measurement or techniques that are on the horizon for resolution of some of the problems.

But once again, I would caution that any application of new, better methods is going to require a lot of understanding when we try to establish comparability between those new methods and the standards and techniques that we have now.

MR. LASKIN: Thanks very much, Dr. Chatfield.

Does the Commission wish to take a short recess?

DR. DUPRE: We'll take the usual break.

THE INQUIRY RECESSED

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THE INQUIRY RESUMED

DR. DUPRE: Counsel, do you wish to proceed?

MR. LASKIN: Sure. Thank you, Mr. Chairman.

MR. LASKIN: Q. Dr. Chatfield, could I just briefly go back to the point you were making just before the coffee break, about the phase contrast fiber count method being inappropriately applied in the environmental setting?

Could you just elaborate on that as to what you mean by that? I'm not certain I completely understand what is set out at paragraph three point three.

THE WITNESS: A. Well, first of all, the asbestos fibers found in the environment...in other words, the ambient environment, not the workplace, generally all have diameters below the detection of optical microscopy. They are usually one, two, three fibrils of diameter..no very large bundles. The only thing you ever see by optical microscopy is a bundle of fibers.

I think there is some pressure to work to levels below point one fibers per mil as a detection level, and so it is an inappropriate technique because you are going to find fibers anyway, and we don't know what they are.

The ambient methods that have been specified in the U.S. and indeed in Ontario, to meet the point zero four fiber per mil criteria, is an electron microscrope, a transmission electron microscope count of all fibers.

We may be expressing it as fibers longer than five micrometers, but it is identified total fibers longer than five micrometers, total asbestos fibers. The identification criterion is to some extent left to the operator, but they are identified asbestos rather than total fibers.

Q. So are you saying that the identification criteria may not be precise enough, leaving some room for judgement in the operator, and you may be measuring things other

Q. (cont'd.) than asbestos?

A. Yes. Or perhaps even leaving things out which are asbestos. It could be either way.

The topic of fiber identification in electron microscopy is being considered by the International Standards Organization working group. I, myself, have a responsibility to the U.S. EPA to write up the water method before August this year, and fiber identification will be a major portion of that document.

Q. Can we turn to the question of fiber type and measurement, and can I ask you this - is there any tendency amongst the various fiber types to have different dimensions? Does crocidolite, for example, tend to have a different diameter than amosite or chrysotile?

A. Chrysotile tends to have the thinner, more flexible fibers. The next one would be crocidolite, which tends to have thinner fibers than amosite. I think that's the only general conclusions one can draw.

The fibers of the amphiboles are generally more brittle, and display cleavage or breaking much more readily in length than the chrysotile will.

Q. It has sometimes been said that they are also more dusty. Is that in accord with your examination?

A. Yes. It's a subjective thing because we have no really good way of measuring dustiness, if we are going to call it that, but certainly I would be more careful handling amosite and crocidolite in a laboratory than I do with chrysotile.

The reason for that is that if you handle the material you note that dust is released from those two materials much more readily.

Again, it's a subjective judgement.

Q. I see. Well, does that mean that chrysotile has a greater ability to settle, as it were, and not remain in the air? Is that the other side of the coin?

A. It would be the opposite. It would be the opposite. Chrysotile has...the amphiboles would have a greater tendency to become airborne, but their larger diameters would give them a greater tendency to settle out as well.

DR. DUPRE: Could you just repeat that?

THE WITNESS: The materials are brittle. In handling you notice that dust very readily is emitted from the materials as you are handling it, but the settling rate is going to be a function of diameter. As the diameters get bigger, that dust is going to fall out of the atmosphere more rapidly than it would with chrysotile.

DR. DUPRE: If the amphibole...

THE WITNESS: If they were single fibers, but you see we also have to take into account the problem that chrysotile aggregates extremely easily into these random oriented bundles and aggregates of various kinds. Of course as they aggregate, then the falling velocity of the aggregate is much larger. So it really totally depends on the degree of subdivision of the material.

But certainly from the handling point of view, handling amosite and crocidolite, I would say that you...that this is something that I avoid doing in the laboratory. I usually do that in a fume hut. I'm not so concerned about handling small quantities of chrysotile.

Q. And that goes to the issue of cleavage or breaking up?

A. Yes.

DR. DUPRE: Could we go very slowly here? Just for a start, why do you say, Dr. Chatfield, that you are not quite as concerned about how you handle chrysotile in a laboratory situation, as distinct from the amphibole?

THE WITNESS: Our experience in handling the

THE WITNESS: (cont'd.) materials, say we're being presented with insulation samples for analysis, the experience is that in handling the material is sufficiently brittle, amosite and crocidolite in particular, are sufficiently brittle that small parts of these fibers as it's being handled, when they cleave away from the main fiber have a springiness to them and they get thrown off into the air.

Chrysotile is a very flexible material and in fact is generally present as very long, flexible fibers and one doesn't get this kind of thing happening. It tends to stay together as a large aggregate.

MR. LASKIN: Q. It does not cleave as much?

THE WITNESS: A. I wouldn't like to use the word cleavage for chrysotile.

Q. But it doesn't break up into smaller fibers with the same frequency as crocidolite?

A. We have a different structure here. Chrysotile is not a single crystal which is being cleaved. Mineralogically, chrysotile is a sheet of silicate which is rolled up into a scroll, and the chrysotile mineral is a number of these... a lot of these scrolls placed parallel to each other. That comes apart very readily. If you take a lump of chrysotile ore straight from the mine and put it in some detergent, then that chrysotile will open, it will come out, open up into individual fibrils very easily. The amphiboles won't do this. The amphiboles basically are crystals which are being cleaved.

The only reason why it breaks up into very thin fibers is that there are a lot of defects in the structure which give weaknesses down this particular direction.

Q. Amphiboles?

A. The amphiboles.

DR. DUPRE: I just must plead for going very slowly at this point. Let me put to you, Dr. Chatfield, what I

DR. DUPRE: (cont'd.) believe I understand from what has been said in the last three or four minutes.

I'll summarize it under two propositions. Proposition number one is as follows: amphibole fibers are more likely to become and remain airborne than chrysotile fibers. Proposition number one.

Proposition number two: Although proposition number one is true, the problem with amphibole fibers is that they are more likely to cleave or otherwise break up into smaller fibers or fibrils which, of course, will have a propensity to become and remain airborne.

The amphibole fiber, as I take it from proposition number one, tends to settle more than chrysotile, correct? But on the other hand, the amphibole fiber if it breaks down can contaminate the air by being airborne?

THE WITNESS: I think the problem here is whether we are talking about a single fiber. If we talk about a single fiber, the falling velocity is totally a function of the diameter. If you have a larger diameter distribution in amphibole fibers...in other words, if the diameters are all larger, the material is going to fall out faster.

I don't think that should necessarily be related to the handling problem. The handling of this material means it is a sufficiently different characteristic. What that characteristic is, is probably its brittleness.

But when you are handling large quantities of the material, it does become airborne more easily. It detaches from the main bulk of the material that you are handling.

MR. LASKIN: The amphibole?

THE WITNESS: Yes, the amphibole.

DR. UFEN: Don't we have to be a bit careful? When we are talking about amphiboles, do you remember the chart you just showed us today, amphiboles cover a spectrum from tremolite

DR. UFFEN: (cont'd.) to amosite.

THE WITNESS: Yes.

DR. UFFEN: I've seen tremolite that doesn't do any of this. You are talking about crocidolite, aren't you?

THE WITNESS: Yes. We are talking crocidolite and amosite...and perhaps anthophyllite.

DR. UFFEN: Now amphiboles included a whole lot of things. It included those which aren't even fibers.

DR. DUPRE: You are just talking about two amphiboles?

THE WITNESS: I am talking about fibrous amphiboles.

DR. UFFEN: Some special fibrous amphiboles. You are not including tremolite, are you?

THE WITNESS: I would include fibrous tremolite, yes.

DR. UFFEN: Do you believe there is that much difference between fibrous tremolite and fibrous chrysotile?

THE WITNESS: Yes. Chrysotile is a very, very flexible material. It gives aspect ratio..chrysotile gives aspect ratios...you can have single fibrils which are four hundred angstrom units, point zero four micrometers in diameter, and yet tens and twenties and even hundred of microns long...aspect ratios of thousands to one.

We don't see that so readily with things like crocidolite. You tend to get...or particularly amosite...you tend to get much thicker fibers, not going down to the...not many of them down in the vicinity of the point zero four. So settling velocity of amphibole fibers generally one would assume was larger. In other words, settle out more readily than chrysotile.

But chrysotile does have this ability, because it ...I don't know whether it's flexibility or what...has an ability to aggregate very readily.

MR. LASKIN: And that...

DR. UFFEN: Are we discussing something that has actually been measured? Have aerodynamic experiments being...are we discussing something that has come out of your observation in the lab?

THE WITNESS: Partly that, but Timbrell has published a rather eloquent paper in which he did measurements of the falling velocities of fibers, and this is the paper in which he in fact identifies the diameter as the criterion, rather than the length.

MR. LASKIN: Q. Can I just put one more proposition to you, and tell me whether it's completely wrong or is fair. This ability of chrysotile to aggregate means that its settling capacity may be greater than the settling capacity of the amphiboles?

THE WITNESS: A. Quite possibily, in the aggregated form, yes.

Q. In the aggregated form.

A. Though the single fibril certainly will remain suspended...well, I won't say forever, but almost indefinitely because there is no falling velocity. But in the case of the aggregate, when these things come together they form a larger entity which has a falling velocity more closely defined by the actual diameter of the entity.

Q. Is that capacity to aggregate, does that and I don't know whether I'm taking you away from your area of expertise or not, and certainly tell me if I am...but is that ability to aggregate more often seen in the mining situation as opposed to the downstream uses of asbestos?

A. I think we probably see that in the downstream use where you are dealing with single fibers. In other words, in the more processed form the aggregation problem or the aggregation effect is something which is going to get more significant.

Q. In the processed form?

A. Yes.

DR. DUPRE: May I ask a less than kindergarten question, a junior kindergarten question? One thing that I appreciated awhile back when I first started to learn about this subject, is that I understand the definition of a fiber is one that has an aspect ratio of three-to-one or greater, and if it was below three-to-one, it would be called a particle, right?

THE WITNESS: Yes.

DR. DUPRE: Is there something similarly convenient and simple that enables you to understand what a fibril is, as distinct from a fiber?

THE WITNESS: Fibril has been generally applied to chrysotile where the structure is entirely different. This is a scroll and the single unit fibril of chrysotile is something which is very obvious in the electron microscope. It has a structure.

The other minerals, the amphiboles cleave along weak directions and give you lumps of pure crystal. In other words, single crystal material which may very well have maybe two crystals down the length of the fiber, which are joined together, called a twin...there may be substantial twinning along the length of a fiber...but it is in fact something which can be broken down again and is totally controlled by the density of the defects in the structure.

With chrysotile, there is no question. Every fibril I pull off a piece of chrysotile is the same. It looks the same and it has roughly the same diameter. It just depends on how many turns on the scroll there have been in the actual formation of the material.

DR. DUPRE: So the term fibril then, is simply a term that is used to describe a chrysotile fiber and that is so used because of its shape?

THE WITNESS: That's the way I would use it. Certainly it may have been used loosely in other ways.

DR. DUPRE: But at this point, presumably, the term fibril has no particular connotations either in the realm of epidemiology or standard setting?

(REPORTER'S NOTE: No audible reply to this question.)

DR. DUPRE: Thank you.

DR. UFFEN: Could I get a tidy up bit about this settling rate and so on?

You mentioned Timbrell?

THE WITNESS: Timbrell, yes.

DR. UFFEN: Would that be the paper that's in your references here, the third one...

THE WITNESS: Oh, yes. It may be.

DR. UFFEN: "The Inhalation of Fibrous Dust", in the Annals of the New York Academy of Sciences, 1965?

THE WITNESS: Yes, that's the one.

DR. UFFEN: Now, 1965, that's fifteen, sixteen years ago and an awful lot of work has been going on in this area. Are there other papers where people would have followed that up?

THE WITNESS: Not that I am aware of in the settling velocities of cylinders. We are, in fact, looking at the moment in one of our research projects, we have in fact been looking for a means of..well, we want effectively to find out what the resistance is to the motion of a cylinder in a viscous medium, and that is data which is almost impossible to get hold of. There seems to have been no work, other than Spears, according to Stokes, and perhaps some extrapolations of that to ellipsoids of revolution. We just don't have any good data on settling of cylinders.

DR. UFFEN: Not even in the aircraft industry?

THE WITNESS: Not really. And you have to

THE WITNESS: (cont'd.) bear in mind even if it was in the aircraft industry, we are dealing with fibers here which are of the order of the mean free path of air, and all of the theories tend to fall apart there.

DR. UFFEN: Almost in the area of...where aerodynamics doesn't apply.

THE WITNESS: Yes.

MR. LASKIN: Q. Is there any tendency for there to be a different size distribution as between fibers that we measure and fibers that are there that we don't measure, as between the amphiboles and chrysotile?

THE WITNESS: A. I'm not quite sure what you mean at that point.

Q. If you take a filter and you look at the fibers greater than five microns in length with a three-to-one or better aspect ratio, you've measured something and there is a whole bunch of smaller fibers or fibers that don't meet the aspect ratio that you told us about. Is there any tendency for that percentage distribution as between those fibers and fibers you measure to be different, as between the amphiboles and chrysotile?

A. Yes. The diameters of the amphiboles are always larger. There is a shift to large diameters and you will in fact see more by the phase contrast method in the case of amphiboles than you do in the case of chrysotile.

Q. So that ...

A. You'll see a greater proportion of the total.

Q. With the amphiboles?

A. For two reasons. One is, the diameters are larger, but also the refractive index of the amphibole fibers is different. It's a higher refractive index and they are more visible in phase contrast.

DR. DUPRE: Hence, among other reasons, the comment in your paper about the proposed Ontario standards if

DR. DUPRE: (cont'd.) you are using phase contrast microscopy.

THE WITNESS: Sorry, I didn't understand you.

DR. DUPRE: What you have just said once again helps to explain the statement that you have in the paper you brought this morning, concerning the proposed Ontario standards... page twelve.

THE WITNESS: Yes.

MR. LASKIN: Let me try another question. Some of the witnesses on health effects, that we have heard from in the past few weeks, have suggested that the epidemiological studies show that crocidolite more often causes pleural mesothelioma or peritoneal mesothelioma than does chrysotile. Is there something in the structure of the fiber, of the two fibers, and the ability of the fiber to get to the pleura or to the abdomen that, in your judgement, would lend some support to that conclusion?

THE WITNESS: A. Well, there are two things chemically. One is that chrysotile itself is a reactive material. In weakly acid environments, the magnesium component of the chrysotile can be leached away. You can actually lose the magnesium, leaving just a very fragile silica shell. And then the fiber breaks up and that's the end of it.

It may leave a shell will looks morphologically in electron microscopy, looks like a chrysotile fiber. But we are not able to prove that it is one, because we don't have any magnesium there, and the removal of the magnesium has also destroyed the chrystalline structure. So we are unable by any technique that we have to demonstrate that this structure that we see is in fact an asbestos fiber, even though it looks like one.

The amphiboles do not have this ability. They are resistant to weakly acid environments, and they are also more

A. (cont'd.) rigid. There are quite different properties to chrysotile and crocidolite.

One comment I will make is that some of the work we are currently involved in is aimed at measurement of asbestos in water. But in actual fact, by accident we have run across an effect that may be significant. That is, that if you take a chrysotile dispersion which is not sterile...in other words, there is a fair amount of biological activity in the water, it's got a lot of bugs in it...and it's in a plastic bottle and you shake it manually or shake it on a laboratory shaker for a period of twenty-four hours, all of the fibers are removed from suspension. They are actually scavenged by the biological organisms in there, and stuck to the walls of the container.

Now, our interest is in, totally, the measurement aspect because we have been measuring asbestos in water and this is an important characteristic.

We seem to have some information that it separates chrysotile quite specifically from other material in the same sample. So in other words, we may have other particles of silica, clays and other materials like diatomaceous earth present from the filtration plant, in the water. But the chrysotile is separated specifically by this method, to the walls of the container.

We have some evidence that this is happening with amosite and crocidolite as well. It seems that we accidentally stumbled on something here which may indicate that asbestos, quote "asbestos", however we define it, is in fact separated by these organisms and stuck to the walls of the container.

Our interest, as I say, is to use this mechanism as a separation technique for the analysis. We realize it may have other implications.

But there are some indications that there perhaps

A. (cont'd.) some properties here that are not fully understood.

DR. UFFEN: I may have missed what you said. This is with both amphiboles and serpentine?

THE WITNESS: Yes.

DR. UFFEN: Both?

THE WITNESS: Both.

DR. UFFEN: I have some questions that may or not be appropriate here.

MR. LASKIN: I was just going to get Dr. Chatfield, if he could... because I think he started off by saying there were at least two reasons why crocidolite may get down into the pleura, and perhaps he can just give us the second reason.

DR. UFFEN: Mine would follow that.

THE WITNESS: I can't remember what the first was now. What was it?

MR. LASKIN: Q. As I understood it, you were talking about the ability of chrysotile in a weakly acid environment...

THE WITNESS: A. Oh, yes, to be resolved, yes.

Q. All right, resolved. I take it when you say a weakly acid environment you mean inside...

A. Oh, it will be in the lung fluid, yes.

Q. It could be in the lung fluids which would be that type of environment and would enable chrysotile to dissolve more readily?

A. Yes.

Q. All right.

A. The other reason was that the amphiboles generally are much more rigid, and as opposed to chrysotile going in as a single rather flexible fiber which is chemically subject to attack, we have the concept of an amphibole fiber which is

A. (cont'd.) not attacked chemically, and which is very much more rigid and obviously has different properties.

Timbrell has published another paper, and I don't know whether you have it in the files, but concerning the relationship of the mesothelioma incidences in South Africa...

Q. I was going to ask you about that, because as I recall...and it may not be that paper...as I recall, if it wasn't Timbrell it was someone, looked at two separate crocidolite mining areas in South Africa.

A. That's Timbrell.

Q. And found some very dramatic evidence of mesothelioma in one area, and virtually none in the other.

A. He also tabulated the falling speeds of the two airborne distributions.

Q. What was his conclusion?

A. He came to a conclusion that the highest incidence was in an area where the thinnest, smallest diameter fiber was present.

Q. Does his...I'm sorry, I've put Dr. Uffen off...but does his conclusion then suggest that even take crocidolite alone, we may get some very different effect depending on the fiber size dimension?

A. Oh, yes. It would mean that if, assuming that the two size distributions were...I can't remember the actual numbers, but I have an idea that the dimensions, the actual diameters were determined by electron microscopy, and one of those at least, I don't think, was going to be seen optically, or was very marginal. So here's a situation where you may have two very different incidences of disease, but fiber counts which run directly contrary to that.

DR. UFFEN: While we are exploring the peculiarities of the crocidolite, I would like to go back to the chemical composition for a minute. When you look at the

DR. UFEN: (cont'd.) differences between the chrysotile and amphiboles in general, is there any significance, or should we forget about it, to the fact that the silicon and the oxygen are quite differently combined? $SiAO^{22}$ as compared with $Si^{2}O^{5}$. Does this imply a chrystal structure which is vastly different and might affect the chemical properties? Might affect the biological activities?

THE WITNESS: Oh, yes. It does imply a difference because the amphiboles are in fact a chain silicate and the chrysotile is a layer silicate.

DR. UFEN: Now, if you split up a chain silicate and a layered silicate, would that affect the properties of the surfaces that became exposed?

THE WITNESS: Very much so, because this is one of the reasons why at the moment we are not able to understand these initial experiments on the biological extraction of chrysotile from water samples, is that the surface charge on chrysotile is directly opposite to that on the amphiboles.

If one is going by conventional theories, one would say that if any separation is going to be made on the basis of surface charge, then chrysotile should behave totally differently to everything else, practically every other species. So far we are showing that chrysotile is behaving rather similarly to the other fiber species, and we are still in a situation where we don't know quite how to interpret the data.

DR. UFEN: That leads me to the other difference, the iron content and the form in which it occurs. Have you been exploring that?

THE WITNESS: The iron content in chrysotile is normally thought of as being incidental to the structure. In other words, small particles of magnitite, and indeed if you look at the micrograph I showed earlier in some detail, you will see that there is some structure to it...the high magnification chrysotile

THE WITNESS: (cont'd.) fiber picture...you will see there is some structure and one does encounter tiny little very dense areas which could indeed be the centers of iron, little microcrystals of magnetite.

DR. UFFEN: But in the crocidolite where a chemical definition is based on the iron, would that form of iron have different physical, chemical and biological properties?

THE WITNESS: Well, it is structural. It's actually built into the structure, so we are dealing with a different material.

DR. UFFEN: How would you go about determining whether these chemical compositions have any biological implications? Would we do an analysis? Would that...?

THE WITNESS: I really can't answer that one.

DR. UFFEN: But there is then a fundamental difference between the serpentine and the amphiboles, the chrysotile and the cricodilite?

THE WITNESS: Yes.

DR. UFFEN: As to physical length, diameter, and chemical?

THE WITNESS: Yes.

DR. UFFEN: The evidence to date has been that it's the physical dimensions that are the important ones? Is that true? Or that the consensus is to date, or is that still of great controversy?

THE WITNESS: To some extent open. Undoubtedly the chemistry has to have an effect, because we are dealing with different materials here. But I think it's generally agreed that fiber dimensions are the more dominant thing, the more dominant effect.

MR. LASKIN: Q. On that point, on fiber dimensions, apart from what you have already said, is there any difference between the amphiboles and chrysotile that might give

Q. (cont'd.) rise to differing health effects, insofar as you are aware?

A. The amphiboles and chrysotile, as I say, the only difference is that a fiber of amphibole which goes into the lung is going to remain there as an amphibole fiber. It's going to remain in the body, at any rate, as an amphibole fiber.

The chrysotile has the potential to be dissolved. The chemistry is appropriate for it to gradually be dissolved...or at least altered. I think dissolved is the wrong word here.

Q. The explanation that you gave before to me, in relation to crocidolite, I take it, applies equally to amosite?

A. It applies to all of the amphiboles.

Q. To what extent does this ability or capacity of chrysotile to aggregate, which you told us about before, to what extent does that affect its ability to get into the lung in the first place? Is it significant in that respect? I mean, even if it aggregates is it still sufficiently small that we can breathe it?

A. Yes, in many cases. The falling velocity may be such that it in fact gets caught in the nasal hairs and never actually gets into the lungs, but here you are dealing with a mechanical, an actual mechanical catching of a large aggregate. Whereas the smaller ones will in fact go through.

Then, of course, you have to address the fact that if this aggregate, this loosely-held bundle or loosely-held aggregate, is ill treated in any way, like banging into a surface, then there is going to be material which then detaches. It's very much a question of how violently the thing is treated.

Q. You indicated this reaction that chrysotile has to a weakly acid environment, and I take it the amphiboles do not react to acids?

A. Not in any meaningful way. There is a slight extraction in concentrated acids, but it's a very slow reaction

A. (cont'd.) compared with other chrysotile.

Point one normal hydrochloric acid, in fact, is capable of removing about two-thirds of the magnesium in a few hours. It's a very rapid reaction in that case.

Q. I take it that's one of the reasons that you see the use of crocidolite in certain products, that it has this ability to withstand corrosion from acids?

A. Well, acid resistance would be a useful property in some locations.

The amphiboles, incidentally, are also more heat resistant.

Q. Than chrysotile?

A. Than chrysotile. The structure of chrysotile is broken down at a much lower temperature than amosite or crocidolite.

DR. UFFEN: What would the order of magnitude of that temperature be? You say much lower temperatures.

THE WITNESS: About five hundred centigrade. You would have to go to something approximating a thousand to get things to happen to crocidolite and amosite.

MR. LASKIN: Q. When you made the comment during your talk that one had to be careful using the optical microscope to measure fibers when you were not in an environment where asbestos was predominant, and you used the vermiculite example, if you are talking about an operation such as a textile plant that uses asbestos, or a cement pipe plant that uses asbestos, or a friction product plant that uses asbestos, does your observation equally apply?

THE WITNESS: A. Yes, and the principal fibrous species that you are going to see airborne will in fact be asbestos. If, however, you are using cellulose, or other fibrous materials in the same operation, then one would have to be careful about how to

A. (cont'd.) interpret the results. Cellulose itself, or small fragments of that, will in fact be taken for asbestos fibers in a phase contrast count.

Q. That was really my question. From your knowledge, are there other substances which are typically used in those operations which, under the optical microscope, might be mistaken for asbestos fibers?

A. Yes, definitely. Cellulose would be one of those. Not a large cellulose fiber itself. I mean that's very, generally very easy to determine, but cellulose has been generally partially processed and you will see things which are fibrous. If you are counting according to the criteria specified, they will be enumerated and called asbestos in the actual measurement.

Q. Where do you see cellulose? In what type of operation?

A. Well, we have a lot of building insulation has been cellulose/chrysotile mixtures. You will find chrysotile/cellulose mixtures used in some pipe covering, pipe insulation. You will find it in actual textile...the welding curtain type of material, asbestos string sometimes has a component of cellulose.

Q. Are there any other fibrous type materials that come to your mind that might fall into a similar category?

A. I think you would be hard pressed to discriminate some particles of mineral wool as opposed to fiberglass where the fiber diameter is very much more constant than it is in mineral wool, which is manufactured differently. You do have a range of fiber dimensions, fiber diameters, in mineral wool, and in the chrysotile/mineral wool mixtures, which have been very commonly applied to buildings, then once again I think you would have some difficulty in determining whether it was an asbestos fiber or a fragment of mineral wool.

MR. LASKIN: It might be a convenient place, Mr. Chairman, to break for lunch.

DR. DUPRE: Shall we rise then until two-fifteen?

MR. LASKIN: Sure.

THE INQUIRY RECESSED

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THE INQUIRY RESUMED

MR. LASKIN: Q. Dr. Chatfield, before we come to these additional slides, can I just pursue one or two more things arising out of our discussions this morning? I think this flows from what you said, but let me make certain that I understand your evidence.

The capacity of the amphiboles to cleave or to fragment and the fact that chrysotile when it is handled may lose this aggregate phenomenon, did that suggest that the farther you move away from the mine, the more that asbestos is used in other processes, that you will tend to see shorter fibers rather than longer fibers?

THE WITNESS: A. The overall dimensions will be smaller the further you go away from the mine, which is one of the things that I have said. But in a mine or close to a mine, then you are finding things by optical microscopy. But when you go a long way from a mining operation where the material is actively in use, then the things you find are very small fibers.

Q. And small...

A. The diameters are generally very fine.

Q. Finer diameters, smaller fibers?

A. Generally shorter lengths.

Q. Then does that also mean that if you have a particular measurement of fibers using optical microscopy that the percentage of fibers that you are not measuring, compared to the ones that you actually are measuring, will be greater the farther you are away from the mine?

A. Yes.

Q. Just one question about crocidolite. From some of the production tables that we've seen, some of the literature, there would appear to be a substantial use of crocidolite relative to other uses of it, in the cement pipe field. From your knowledge, is there something in the chemistry or something in the fiber that lends itself to that particular use of crocidolite?

A. Chrysotile asbestos on its own apparently does not allow water to drain through the structure particularly well, and I understand that a harsher fiber like crocidolite or amosite is added to assist in the manufacture of products of that kind.

Q. And increases the draining capacity?

A. I believe so.

Q. All right. If we move now onto these additional slides, and I take it these relate generally to the subject of alternative measurement techniques which may be available in the workplace?

A. Yes. There are, in fact, a number of approaches that one can use for improved methodologies for measurement in workplace atmospheres. One of them has been looked at in England by Manchester University people, and has resulted in some software to be applied in an image analysis device which allows fibers to be counted automatically. There is nothing to do with the slide at the moment.

This device is known as a Magiscan, and the people at the health and...what's their name...basically the people responsible for industrial health in the U.K., are in fact using this device using the normal phase contrast image, and there are some calibration difficulties which are being talked about at the moment, but it is a next step in getting at least a reliable number out of the method which can be repeated.

A. (cont'd.) The next step is perhaps to go to scanning electron microscopy, with an image analysis device attached to that. At least we are then going to see all of the fibers, and if an automated system did the actual fiber enumeration then at least we would be getting the same answer each time again. One may set up the rules for counting aggregates, and that would be done once and for all. But the definition as to what to do with aggregates is another problem.

Now these are both fiber counting techniques though. We are still basically dependent on the fact that precision is going to be totally related to the number of fibers we count. If we only count a hundred fibers, we can expect an error of plus or minus at least thirty percent. This is quite unavoidable.

The other approach is to do a measurement based on the work of Timbrell. Timbrell found that magnetic fields are capable of lining up magnetic fibers, asbestos fibers, and many other fibers did not line up. Glass fibers did not line up. And if you place a dispersion of asbestos fibers in a magnetic field, there are three different alignment modes as shown on the slide. One is the fibers align parallel to the field. Then there is a situation where some of them, in some of the amphiboles, line up perpendicular to the field with their lengths perpendicular to the field, which means that in any one plane you have them all held as in diagram B, with complete freedom to rotate but not freedom to turn around so that they are in any sense parallel to the field.

Then the other situation is one where the fibers are held at some constant angle to the field. These are the three modes of alignment which you find when you look at mineral fibers generally.

Now, if we go to the next slide, we are able to prepare from a liquid dispersion...in other words, we take

A. (cont'd.) our sample and somehow get it into liquid dispersion and filter it between the poles of an electro-magnet.

Go to the next slide...that's the equipment and one takes the filter, perhaps ashes the filter, redisperse and filter the resulting suspension onto another millipore filter. That filter is taken and treated exactly by the AIA method, to render it transparent. This procedure does not disturb the alignment of the fibers. The asbestos fibers land up on that filter parallel to the field or perpendicular to it.

Other fibers, such as cellulose, etc., stay in a random orientation.

So here we have taken the asbestos fibers specifically and put them in two known directions, because we can mark the edge of the filter to indicate the field direction.

Next slide, please.

Now, this is a phase contrast micrograph of a crocidolite dispersion which is on the filter. It has been prepared as the normal AIA collapsing filter technique, and these are random orientation fibers.

That slide, in fact, was prepared outside of a magnetic field.

If we then go to the next slide, this is what happens if the same filter, the same dispersion is prepared in a magnetic field, the field being parallel to the...well, the field being approximately horizontal in this case.

You can see that most of the fibers are in fact lined up horizontally, and there are one or two which are vertical on that slide.

Now, if we take that transparent piece of plastic with these fibers imbedded in it, and look at the light scattering behaviour when we illuminate this piece of

A. (cont'd.) plastic, we can...next slide, please...we can set up equipment of this kind where the entire filter is illuminated by a laser beam and we examine the light, the intensity of light scattered at a known angle from the forward direction. If we then rotate the filter, then because the fibers are lined up in a specific way, we will get a different behaviour as the filter rotates. If I show you a light scattering pattern... the next slide, please. Oh, sorry, this is the actual equipment. The laser is, in fact, nearly on the floor there and we brought up a beam so that it's horizontal and aimed at the circular device in the center of the screen, which holds the filter, and then there is a light scattering measurement made by a photomultiplier, at an angle to the forward direction.

Next slide.

Now, if you take the unaligned filter that I was showing you earlier, this is the light scattering pattern. This is just photographed from a screen. The central dot there is absorbing the central beam so that it's not quite so bright. You see there is absolutely no...this is a symmetrical scattering pattern.

Now the aligned filter displays an entirely different behaviour...next slide...and that is the aligned, magnetically aligned filter. Now, as we rotate that filter in the holder, that pattern rotates, and as the bright bar crosses the photomultiplier, we can output the voltage from the photomultiplier and have a pen record, which is giving a measurement of the total amount of magnetically-alignable fiber on that filter.

Now, this is not a fiber counting technique so it's not actually specifically related. We no longer have this error due to fiber counting. This is a measurement of the overall filter.

Next slide.

A. (cont'd.) The pen record would look something like that. You can see there we only have fifteen nanograms of crocidolite per square millimeter on the filter. We have a very good signal. The peak there is from the parallel-to-the-field fibers, and there is a small peak from the normal-to-the-field fibers.

Next slide.

If you look at amosite, there is a greater component of the material lying perpendicular to the field. So the parallel fibers are scattering the vertical line there, and the horizontal line is caused by those which are lined up perpendicular to the field.

Next slide.

And that is the peak that you get from amosite.

One interesting thing comes out of that, and that is that you notice that the smaller peak there is wider than the very tall peak. That's a consequence of a width distribution. We find that the smaller fibers generally give a larger, a broader peak. So those fiber dimensions contained in this graph, we are not sure how to extract that yet, but it is there.

Next slide.

Now, the next improvement which we have now got working, is the concept of not filtering the material onto a filter so much as looking at the liquid suspension of fibers. And in this way we can get the dynamic behaviour of the fibers.

If we have a suspension of fibers in liquid, and then we rotate the magnetic field around a little spectrophotometer cell containing the liquid, the only thing that is doing any rotating there are the actual asbestos fibers. So we eliminate a whole load of problems connected with filter backgrounds and things like that, and we get a signal which is.. we have some extremely sensitive measurements from this device.

The next slide, please.

A. (cont'd.) That's the entire system as set up, and you can see the magnet at the top there. It's a nine point two kilogauss permanent magnet, which we have had to build because there is no such thing on the market.

DR. UFFEN: Did you have to experiment to decide on how much, what strength? Or did you just...?

THE WITNESS: Timbrell's work indicated that about three kilogauss was adequate to start the alignment procedure. We decided the first magnet we would go for as strong as we could, so that we at least didn't have to start again and build a more powerful one.

Now the interesting thing about this is that a fiber which is in a liquid, a viscous liquid, is rotating. There is a resistance to its rotation, and the resistance to its rotation depends on its dimensions. It's a very complicated function of length and diameter.

Now we find that as we rotate the magnet faster, some of the larger fibers are not able to follow this rotation and they get out of synchronism because the viscous drag caused by the liquid overcomes the magnetic talk on the fiber.

So by changing the speed of rotation, we are able to select measurements from different size ranges of fibers. This is for the first time we are able to take an entire distribution and measure some fiber size-related information, as well as a concentration.

As I say, this is a very repeatable technique. The work in principle has been embodied into an instrument marketed by Vickers in the U.K., and partly funded by the European Economic Community. The device which is currently marketed is in fact just a means of outputting the graph which I showed you earlier, the actual reading. It is an uncalibrated system.

THE WITNESS: (cont'd.) What we are aiming for here is a system which will not need calibration. In other words, a calibration provided will in fact give fiber sizes, whatever the size distribution of material you put in.

The Vickers unit has to be calibrated for each separate size distribution that it is used for, so what we are looking forward to here is a more reliable measurement.

DR. UFFEN: What were they calibrated against? When you calibrate it, what do they use as...?

THE WITNESS: Oh, they have to calibrate against the phase contrast fiber count. So a phase contrast fiber count is made, they say the peak size I have here corresponds to five fibers per mil.

DR. UFFEN: But they commonly do it the other way around?

THE WITNESS: I would hope so, yes.

Okay, I think that's the last one. Is it not?

UNIDENTIFIED SPEAKER: No, there's two.

THE WITNESS: Oh. Yes, in terms of sensitivity, this was on the filter technique, we have improved on this since. With crocidolite we are seeing rather less than half a nanogram per square millimeter of filter. These are...this is about eight hundred and fifty fibers per square millimeter, with...we are not... just because it's an optical technique does not mean that we are, in this case, limited by the wavelength of light. This is light scattering. We are not expecting to image from it, so we can in fact go down way below the wavelength of light in fiber dimensions, for this particular technique. And indeed we do have measurements from waterborne dispersions, which only contain single fibrils, and a perfectly good signal from it...even though the average fiber diameter corresponds to one unit fibril at point zero four. So we are only about a tenth of the wavelength of light and we are still getting a good measurement.

THE WITNESS: (cont'd.) Next slide, please.

That is, indeed, a chrysotile curve. It's getting a bit noisy at that point, a third of a nanogram per square millimeter.

DR. UFFEN: When you went from crocidolite to chrysotile, it had to be recalibrated?

THE WITNESS: We would have to recalibrate, yes, at the moment.

DR. UFFEN: For the properties...

THE WITNESS: Yes, yes. Chrysotile does not line up so readily as the other minerals, but it still lines up and gives a perfectly acceptable peak.

That's one of the reasons why we have gone for the very powerful magnet. We realized that chrysotile was going to give us more problems than the amphibole minerals.

DR. UFFEN: This would be primarily because of the (unintelligible.)

THE WITNESS: Yes. One of the interesting things about this method of dynamic measurement is that the concept of a fiber rotating in a viscous medium should be a direct measurement of falling velocity, which is, I think, a biologically important number. Even if we don't relate that to a size, this may be a falling velocity measurement.

DR. UFFEN: In the same fluid?

THE WITNESS: Yes. In the liquid.

DR. UFFEN: Not in air?

THE WITNESS: In air, of course, there may be a problem, there may be some calibration difficulties there.

MR. LASKIN: Thanks, Dr. Chatfield.

MR. LASKIN: Q. Can you, for my benefit, there is certainly a good deal of all of that technical description beyond my ability to comprehend it...could you give me some indication of how practical these alternate methods

Q. (cont'd.) you have suggested are for use in the workplace and indeed whether any other jurisdictions of which you are aware are utilizing them?

A. In the United Kingdom they are using the Magiscan. The basic problem with that unit is its expense. We are talking here of something like a quarter of a million pounds having been invested in the installation, of the health and safety executive in London. That would mean, basically, that a sophisticated instrument is going to be located in one center, and then samples sent in to it, which is perhaps not as satisfactory as we would like it.

The other method I was talking about, the scanning microscopy and image analysis system, again we are talking money. We are talking potentially eighty thousand dollars for the scanning microscope, and you need a computer at about another forty thousand dollars, hanging onto the thing. So we are talking maybe a hundred, a hundred and twenty thousand dollars for that approach, even assuming it's fully developed.

The magnetic alignment method, on the other hand, uses very little equipment. The...we are dealing at the moment with a magnet which first cost us a lot because we were designing it from square one, but we don't need it as powerful as it is there. That could be put together for something like about five or six thousand dollars.

The computer we are using for data acquisition is a domestic computer, the Apple computer, which we purchased for about five thousand. The rest of it is...the laser is an overkill. We happened to have it in the lab. You don't need a laser. A two thousand dollar light source will do you just as well.

So we are really talking about maybe ten to twenty thousand dollars for a complete system, which certainly is as cheap as the optical microscope, and we are also talking about a measurement time of really only a few minutes, on the

THE WITNESS: (cont'd.) instrument. The measurements you saw, the curves, would be obtained in...well, of course, we are now dealing with digital output on this system anyway, an actual number comes out to give us the area under the peaks, and such things.

This analysis time, really, is just a few minutes on the equipment. Sample preparation, we are not really talking a great deal of effort, because you can deal with those by the dozen, so to speak.

MR. LASKIN: Q. Can you summarize for me what the advantages of this magnetic alignment technique are compared to the optical microscope, and on the other side what are the disadvantages that you see?

THE WITNESS: A. The primary advantage would be reproducibility. I think that's absolutely certain.

Precision, not only reproducibility, but also the ability to measure the same thing on two identical samples, as well as the ability to measure the same thing on the same sample. Those two things, definitely.

The removal of the primary cause of error is the, frankly, is the fiber counting and the rules, etc., that we have to deal with. Here we are dealing with a physical measurement which is not a fiber count. It doesn't have the fundamental limitations of statistics.

Q. What measurement is it? What are you measuring?

A. What are we measuring? What we have been measuring here...and as I say, this is one of these things which is still under development so we have to go carefully here...already published is the original Timbrell paper. You can extract an enormous amount of data in a small time, and I have shown a single measurement at a constant angle from the straight-through direction.

Now, if you increase the angle of the

A. (cont'd.) measurement...in other words, increase the angle off axis, which we make our measurement, that is the light scattered at higher angles is from smaller diameter fibers. So we have the potential to make a measurement of fiber diameter, mean fiber diameter perhaps.

We also have the potential, by looking at the speed of rotation versus the signal, to determine the length.

Q. Of individual fibers?

A. No, an average per sample, or the mean for the sample.

Q. So you can get a mean of the length, an average of the length, and an average of the diameter? You will not get an actual fiber count?

A. No.

Q. To go back, I take it the Timbrell paper... you worked from the hypothesis that diameter and length are critical factors in adverse health effects. Is that correct?

A. Yes.

DR. UFFEN: Can I pursue this a bit?

MR. LASKIN: I would be delighted.

DR. UFFEN: Usually it's the other way around.

I'll try to phrase it, and you tell me whether I've got it right or not.

If you are able to get past the experimental stage, choose a sample, a standard sample, against which all the other microscopes, optical ones, could then be prepared, you might even have an agreed international standard analogous to an atomic clock against which all the other clocks in the country could be compared?

THE WITNESS: Yes.

DR. DUPRE: Dr. Chatfield, could you help me as I progress at the moment, or regress, with junior kindergarten questions?

DR. DUPRE: (cont'd.) If this measurement gives you a mean length and diameter of whatever number of fibers are in the sample, is it still not valuable to know how many fibers there are?

THE WITNESS: Of course, yes. I'll agree with you there.

The basic problem at the moment is, we are still working on this technique to try to find out how to take these signals apart to get the data we need.

The total area under those curves, as I showed you, is representative in some way of the total amount of asbestos fiber...the total amount of fiber that is aligned.

If we can also extract a mean width and a mean length, then we have the capability of at least producing some kind of number, a numerical value, based on the total, the total amount, the total mass, divided by the mean volume will give us something like a number.

Now, again, we are never going to get individual fiber counts from this. But for what it's worth, it is a reproducible measurement which will give us something related to a mass, and it will give us the information on fiber dimensions as well.

DR. DUPRE: There is one other thing that I don't understand. If the measurement that is being produced is the mean length and diameter of whatever number of fibers are in there, how does this instrument calculate the mean for you? Doesn't it have to know?

THE WITNESS: It doesn't calculate. This is done by a previous calibration, okay?

DR. DUPRE: Oh, I see.

THE WITNESS: In other words, we have to find out how wide is this curve, what is it's width, for a specific dimension of fiber. This is a calibration, this is part of what

THE WITNESS: (cont'd.) we are working on.

DR. UFFEN: You've got two other variables to deal with, magnetic field and finding what proportion of the samples line up. The other one is, isn't it the intensity of the radiation if you use the laser, but suppose you just keep increasing the intensity. At any one intensity you would get a certain result on your recorder...

THE WITNESS: Yes.

DR. UFFEN: ...so if you have a different number, number not size, of fibers, you would presumably get a different output?

THE WITNESS: Yes.

DR. UFFEN: So if you can't vary a number of fibers, that's what you have got to work with. But it's varying intensity.

THE WITNESS: Varying the intensity merely gives us different signals, proportionally larger signals scattered into the photomultiplier. That doesn't teach us anything about what is going on in the sample.

DR. UFFEN: I had better continue to read my...

THE WITNESS: Variation of the wavelength would indeed give different characteristics, because the scattering is...

DR. UFFEN: You were using two or three different wavelengths?

THE WITNESS: Yes.

The other variable you have is the viscosity of the medium that the particles are suspended in.

DR. UFFEN: Since you talked to us at our public meeting, has this all sort of come to a head since then?

What you are telling me now is quite new?

THE WITNESS: Yes.

DR. UFFEN: Is this true?

THE WITNESS: Yeah, we were working on it at that

THE WITNESS: (cont'd.) time, but...

DR. UFFEN: Have you published any of this yet?

THE WITNESS: March, I believe. Yes, there is one which is in publication.

DR. UFFEN: In press or...?

THE WITNESS: It very soon will be. It's in the National Bureau of Standards document which will be coming out in a few months time.

DR. UFFEN: The big catch is going to be the calibration. From the point of view of this Commission and everybody else, trying to relate what you are able maybe to do in a year or two, to all the data that has been collected means we have to calibrate it against ...

THE WITNESS: Oh, yes.

DR. UFFEN: ...something very difficult, you know, factors of six out.

THE WITNESS: Yes.

DR. UFFEN: So you end up with an instrument in which the reliability is somewhere between one and six, because of the calibration problems.

THE WITNESS: That's what you mean by doing it the other way around. Yes.

This indeed is what I meant when I said, okay, we may be able to produce a good, reliable measurement which is repeatable and represents the amount of fiber in the air, but whether we are going to call it mass...from point of view of control in a plant, mass is probably as good as anything...indeed we probably are measuring mass if we are measuring only those longer than five micrometers, because those are the ones which contribute most to the mass.

DR. UFFEN: I won't push it any further, but is there any indication that this kind of approach might be attractive to the international committee, or is it still regarded as strictly

DR. UFFEN: (cont'd.) experimental at this stage?

THE WITNESS: This is still experimental, except that Vickers, as I say, have in fact put out an instrument which is being looked at by the British very favourably.

MR. LASKIN: Q. Just a few brief questions on the other two methods you talked about. The magiscan method, did I hear you say that that is being used in the United Kingdom?

THE WITNESS: A. Yes. That is a piece of equipment installed at the Health and Safety Executive in London.

Q. And is being used for its fiber counts?

A. Yes. As a matter of fact, that is the... that instrument, I believe, is the origin of the requirement to start calling aggregates eight, up to eight fibers, because that will then make the results from the machine agree more closely with the human operators.

Q. What...just briefly...can you summarize what the advantages are of that machine as opposed to optical microscopy, and what the disadvantages are...and you have already told us about the cost factor?

A. The magiscan, in fact, is based on optical microscopy. It's just an automatic method of looking at the same image. What you do is, you establish a set of counting rules which are built into the computer, and they are always rigidly applied. So from the same picture, you always get the same answer.

The key here is that the magiscan, being a computer, doesn't get tired on a Friday afternoon. Human operator counters do.

Q. Ah, so you remove the error that there is in human judgement?

A. You make it consistent.

Q. You make it consistent, all right.

Do you count the same fibers? That is, only

Q. (cont'd.) fibers greater than five microns in length, with a three-to-one...?

A. The machine is designed to count only fibers longer than five. The question which has cropped up recently is the question of the depth of field, depth of focus of the optical microscope. That is, you remember I mentioned...in fact, Dr. Uffen brought it to my attention...but the, one of the errors that had been quoted about optical microscopy was the failure of the operator to rack the focus up and down on the microscope so that you did in fact search through the entire depth of field of the filter, the depth of the filter, for fibers. The machine, of course, looks at a single focal position. It doesn't do any racking up and down. It's not that sophisticated.

So the question has arisen, is the machine actually counting the same features that a human being does. That question has not been satisfactorily answered yet.

Q. Does the machine have the capability to count fibers smaller than fibers greater than five microns in length with a three-to-one ratio?

A. It won't go down below optical visibility, obviously, but it is certainly...it should be able to get some kind of sizing out of it. Now, how low you can push that I really don't know.

When you get down to very small fibers, what you tend to find is that there are a lot of filter artifacts, actually portions of the, or structures in the filter that you are not at liberty to discriminate from fibers. Under these circumstances, the smaller you get, the more of these you find.

Q. To your knowledge, have the British done side-by-side comparisons of the counts that you get with the Magiscan as opposed to the counts which you get with ordinary optical microscopy?

A. Yes, they have. Yes.

Q. Are they finding a trend?

A. The machine initially produced...this is work done at Manchester University...initially produced counts which were somewhat higher than the human operators were producing, and indeed the way that they got over this...well, I won't say it's a problem...was to degrade the properties of the objective lens of the microscope.

The situation was that the actual human counts were being made in one laboratory on one set of microscopes, and the counts on the same samples on the Magiscan were being done on a superior grade of microscope. It was a research microscope.

Consequently, the Magiscan was seeing more fibers than the human operators were, so this was...at that time... strictly thought of as a difference in microscopes. It was possible to get the two numbers to run reasonably parallel.

Q. I see. And it has the advantage of consistency?

A. Yes.

Q. What is happening in the Brish workplace is that samples are all being fed into this central machine?

A. No, that's impractical. That's just for the government control purposes. I believe that the people at Turner Brothers have in fact purchased a Magiscan as well.

Q. I see. Then the other method that you spoke of, scanning microscopy, is that still in an experimental stage or is that a method that is being utilized anywhere?

A. That's still experimental.

Q. Just very briefly, is it something that we can expect on the horizon very shortly, or is there still a lot of work to be done?

A. Not a lot of work to be done. See, one of the things here is that the business of crossed fibers has to be

A. (cont'd.) addressed. Where you have the fiber aggregates, there are a lot of fibers crossing each other. Human operators find that difficult to deal with. A computer finds it relatively easy, if it's programmed to do it.

The image analysis devices on the market so far have never been able to handle this kind of problem. The system we have got, it does in fact take the aggregates apart and report the fibers separately, as best it can. It would do as good as you or I would do with a diagram.

Q. I take it...will it report fibers of all sizes?

A. Yes.

Q. Because it's not optical?

A. No.

Q. Will it report by fiber type?

A. Yes, it can. I say it can, we already have this programmed into the machine. It does, in fact, measure the composition of each fiber as it does it.

Q. Is the international community looking at this method?

A. Not yet.

Q. Not yet.

One other...just to get away from these methods for a moment...but one other question I wanted to ask you about, counting. When Mr. Berry testified before us, he spoke about the various dust levels and fiber counts at the Rochdale Textile Plant. As I recall, during cross-examination one of the papers that was put to him was a recent paper by Peto, which suggested, as I recall it, that if one counted or measured first of all using personal sampling as opposed to area sampling, and if one also used a graticule method of measurement as opposed to a full view method of measurement, that one would get considerably higher counts. That is, graticule over full view and personal sampling over area

Q. (cont'd.) sampling would both give you higher measurement counts, and therefore Peto attempted to recalculate the dust levels that had been previously seen in epidemiological studies at Rochdale. I can't recall the figures, but they were certainly higher.

Does that accord with...I mean is that a reasonable conclusion to come to, in your opinion?

A. Yes. The full field versus the graticule count, immediately you go away from the center in an optical microscope field, then you are going to peripheral optics where the resolution is not as good as it is in the middle. If you do a full field count, you will not see the smallest fibers in the outer parts of the field of view.

By doing a graticule count, you are at least confining your observations to the best region of the optics, so you are able to see as well as the microscope will let you see.

The question of personal samples rather than the static, the position samples, generally our observations have been, at any rate, that if the sampler follows the worker, then there is a higher number comes out.

Q. Can I just finally, because I don't want to detain you too long, just ask you one or two general questions about some of your studies in relation to the environment? I know you did a major study or participated in a major study on drinking water supply systems. Can I just ask you as a general conclusion, or let me ask you the question first, in respect of Ontario alone, how many systems did you look at?

A. Do we have that here?

Q. I think so.

A. I can't remember...

Q. Tab eleven.

A. Sorry?

Q. Tab eleven.

A. Tab eleven?

MISS KAHN: That book right there.

THE WITNESS: A. Oh, okay. I've just got it. Okay.

Yes, if you see on page nine of that document, at eighteen locations in Ontario...locations which represented fifty-six percent of the provincial population.

MR. LASKIN: Q. May I ask you just as a general conclusion, whether you did conclude one way or the other whether there was any problem, if I can use that term with all that it connotes, but was there any problem insofar as you were, found in any of these systems in Ontario?

THE WITNESS: A. I won't use the word problem.

I would say that the majority of the locations where the...the concentration were essentially zero. In other words, they were close to our detection levels.

I remember two exceptions. one of which was Thunder Bay, which gave, I believe, two or three million fibers per liter.

The other one was Hearst, Ontario, which the water was a difficult problem of analysis, and one of the things that I have not mentioned in the general context of detection levels, if there is a lot of other suspended material in water, then...and you are looking for a few asbestos fibers...you are forced into a specimen preparation where the detection of one fiber is going to correspond to a high concentration of asbestos. That is not a very satisfactory way of reporting the result, but really there is no alternative at this time.

Hearst was a situation where one fiber would correspond to a reasonable concentration of perhaps point three or point four million...I can't remember the actual numbers.

Tilbury, Ontario, was an extreme case of that, where the water was so dirty in other respects that the one fiber

A. (cont'd.) found in that analysis, I believe, corresponded to seven million per liter, and really you cannot place any reliance on that kind of measurement.

So those were really the only high numbers... "high", quotes...which were found in Ontario, and the rest of them were at essentially the detection level.

Q. Can you give us some context of the significance of the levels at Thunder Bay and Hearst?

A. Detection levels we aimed at were approximately point one million fibers per liter. That's ten to the five fibers per liter. In Thunder Bay, Ontario, chrysotile asbestos was running up into the two point eight million per liter in the distribution system. I've always preached the philosophy that one does not regard fiber counts as a single number. You always regard it as a range, and you will see that...

Q. What page are you on?

A. Hmm?

Q. What page are you on?

A. I am...oh, it's not numbered. It's probably in the appendix and the number isn't reproduced.

DR. DUPRE: Table six, page thirty-one.

THE WITNESS: Sorry?

DR. DUPRE: Table six, on page thirty-one?

THE WITNESS: I don't have a number on this.

MR. LASKIN: Q. Are you on the Results of Analysis?

THE WITNESS: I am on the results, yes. I am in the results section.

Q. On Thunder Bay?

A. Yes. These are generally very low. You see that in some cases the ninety-five percent confidence interval extends essentially to zero.

Q. Meaning that the measurements that you found

Q. (cont'd.) would not be statistically significant?

A. They are not statistically different from zero.

Q. From zero.

Does the same general conclusion apply to Hearst?

A. I'll just look at that. Hearst? No.

No, in the case of Hearst, the results are quite significant. The question here crops up of how we have defined asbestos. The methodology as specified are that we have to be able to demonstrate that some fibers in the sample are the species that we are counting by selected aeroelectron diffraction.

We did find identified asbestos fibers in these samples, but the majority of the fibers counted, you see sixteen, fifteen and ten...were in fact just identified on the basis of morphology, but they were similar to the ones which were identified.

Q. Was there, to your knowledge, any remedial action of any kind taken either in Thunder Bay or in Hearst, following the publication of this study?

A. Not to my knowledge.

DR. DUPRE: You would recommend...did you recommend any?

THE WITNESS: I didn't recommend any. It wasn't my terms of reference to make recommendations. Certainly...let's put it this way...I would drink the water. It is the main problem that we are concerned with in that case is not the asbestos.

DR. UFFEN: Is it correct that the figure you did obtain meets the current regulations for fiber counts in air? I think...two point one times seven-six fibers per liter, or the equivalent two point one fibers per c.c., if this had been in air, was comparable with the existing guidelines or regulations?

THE WITNESS: There are not regulations for water.

MR. LASKIN: That was going to be my question.

THE WITNESS: There are no guidelines or regulations, to my knowledge, for water.

DR. UFFEN: The regulations that used to exist in Britain, two fibers per c.c., close to that?

THE WITNESS: You would be talking about two thousand per liter in that case.

DR. UFFEN: Two thousand?

THE WITNESS: Yes. We are talking two million here.

DR. UFFEN: Right. Thanks.

MR. LASKIN: Q. Are there jurisdictions which do prescribe a standard, to your knowledge, for concentrations of asbestos in water supplies?

THE WITNESS: A. I'm not aware of any.

DR. UFFEN: It would be significant, even though it's a thousand times greater, you would be drinking it, not inhalingit?

THE WITNESS: Yes.

MR. LASKIN: Mr. Chairman, those are all of the questions I have.

DR. MUSTARD: Excuse me, one thing. Could you contrast Thetford Mines with Thunder Bay? In that water analysis?

THE WITNESS: Why do you select Thetford Mines?

DR. MUSTARD: Because Thetford Mines has got about a hundred times as much asbestos fibers in your calculations. If you said what you did about the water supply in Thunder Bay, what about in Thetford Mines?

MR. LASKIN: He wants to know whether you would drink it.

THE WITNESS: Oh, yes, I have.

If you look at Baie Verte, Newfoundland, you'll find it even more impressive.

DR. MUSTARD: You can include that in your

DR. MUSTARD: (cont'd.) comments as well. Is that a significant level?

THE WITNESS: It's a very measurable level. I think the question we have to address is that no one has laid down any health-related observations for drinking water, as yet. I think it requires epidemiology to see if there is any difference between disease incidence and these different locations.

MR. LASKIN: Q. Just one other question, I'm sorry, just on perhaps a different point in the environment.

Has, or have you been engaged in any air sampling in the general environment with respect to asbestos content?

THE WITNESS: A. Yes. Well, we've done quite a lot of work on the schools issue, of course. This has involved taking air samples inside buildings - not only the schools, but also a number of commercial buildings, airport buildings, this kind of thing, in order to give a measurement of what the airborne concentration of asbestos is. We have also been involved in the... you probably have copies of the document...the airborne work that was done in the Toronto subway.

Q. Yes.

A. I think that's all I can recall at the moment.

Q. Are those measurements in fibers, or are they fiber-count measurements?

A. They are fiber counts.

Q. Your work with respect to measurement in buildings, is that yet published?

A. No.

Q. And will be...?

A. Except in some of the individual school boards, of course, they may very well have the data for release.

Q. Yes. Can you just generally, can you recall the kinds of levels that you were finding in schools?

A. Whether the asbestos has been removed or whether it is still there, we seem to...we are able to meet the Ontario environmental guideline of point zero four fibers longer than five micrometers, in practically every situation. I don't... on a number of occasions we have found that after removal the levels were actually elevated as a consequence, presumably, of not an adequate cleanup of the building after the removal.

But we have not gone into a building and taken air samples and found any concentration which exceeded the point zero four governmental guideline.

There are always fibers, but then there are always fibers outside the front door as well. Not many, usually going up to perhaps, maybe point one or point two fibers per milliliter, sometimes a little higher. But they are all small ones, very rarely coming across a background fiber longer than five.

Q. These are for school boards you have already dealt with and given the results to, I take it?

A. Yes.

MR. LASKIN: Thanks, Mr. Chairman.

DR. DUPRE: Thank you, counsel.

Have the parties got a batting order for me?

MR. McNAMEE: Yes, I'll go first, Mr. Chairman.

DR. DUPRE: Mr. McNamee, you are going to lead off?

MR. McNAMEE: I would like to introduce, sitting on my right, Mr. Tom Pang, who is the senior scientists with the Occupational Health Laboratory, Ministry of Labour, and he just took delivery of a new electron microscope this morning so he is very interested in the evidence given that his microscope does both the TEM and SEM, so I guess that's a little bit...a fairly sophisticated model.

CROSS-EXAMINATION BY MR. McNAMEE

Q. Just to...you were talking about the schools and measurement of the environmental level, which is point zero four fibers per c.c. greater than five microns in length? Is that correct?

A. Sorry. Would you say that again?

Q. The standard that you are using for the school testing, you are using the environmental standard of point zero four?

A. We have, in any reports we have issued, we have compared the levels we got with that particular level, in the absence of any other information.

Q. Are you measuring this with electron microscopes, or the optical, using the optical measurements?

A. Using electron microscopy. We have taken the view that we will not do phase contrast outside of the workplace.

Q. Well then if you are using this electron you are probably getting...you are getting higher readings relevant...your point zero four with the electron microscope might work out to point zero one with the optical, in view of the fact that you have indicated that the optical microscope doesn't pick up a lot of...?

A. Well, let's look at it another way. We would perhaps be getting the detection limit of the optical microscope. In other words, the result saying not more than point one, which is the only thing you could say optically, versus an actual measurement of the number of fibers by the electron microscope, and indeed we may very well still be saying less than point zero four. But in actual fact, most of our reports will in fact be less than point zero zero four. In other words, we have aimed our measurements at a factor of ten, less concentration than the Ontario guideline.

Q. Yes. And you were speaking about water sampling. Would it be fair to say for the particles you are talking about, and these water samples, would be more fibrils rather than fibers and you could see them only under the electron microscope, most of these water particles?

Would you be able to see them under the optical microscope?

A. You would not see fibers...fibers in water samples you will not see in an optical microscope at all.

Q. They are small?

A. Very, very small. The mean length is usually around two micrometers.

Q. Let's go back to the electron microscope. You've already indicated the initial capital cost, and in view of the fact that some of these workplace environments you might want to have a number of samples each day, say over the course of a number of day, how long does it take with the electron microscope to analyze a sample? How many hours?

You have indicated...

A. Yes. I think, again, I think we have to look at the thing as to the measurement we are trying to produce. In a workplace sample the requirement for identification would not be anything so large as it is in an environmental sample. A count done on an electron microscope, whether it be a scanning or TEM, would be not sigificantly higher than that on a phase contrast microscope, provided we were not indulging in identification.

We have to count a certain number of fibers. The one thing I would say is that the fatigue effect on the operator might be a lot less using electron microscopy than using the phase contrast.

The actual time for an environment sample, involving all the identification procedures, would be something of the order of about three to four hours on the microscope, and

A. (cont'd.) maybe an hour or two of specimen preparation at the front end. So you are talking an expensive analysis.

Q. Say a test, like a three or four hour test like you are talking about, what would that cost, five hundred dollars?

A. Approximately. We are charging four-fifty at the moment, and that kind of number.

Q. Mr. Pang gave me a question, so if I stumble a bit on it I hope he helps me out.

He has indicated to me that...maybe you can correct me if I'm wrong...that some amphiboles in their natural state are not fibers, and he suggested riebeckite and tremolite when it's mixed with talc.

A. Before mining?

Q. Yes, before mining, that you often find these are similar in chemical composition to some of the asbestos-type amphiboles...like crocodilite, but they are not fibers.

A. Yes, that's quite right.

Q. That in the mining process that these substances might be crushed and then become fibrous and airborne?

A. Yes. I don't like the word 'become' fibrous. Could I...I would have to refer you at that point to a paper by Wiley, from University of Maryland, who had in fact taken fibrous and nonfibrous amphiboles and crushed them and produced aspect ratios distributions to try to discriminate between the fibrous and the nonfibrous versions.

This is a bit of a problem because the chemistry and the chrystallography are practically identical.

Q. Would it be fair to state that in testing adherence to proposed standards that when these...if I can use the term...when these amphiboles became fibrous...and again

Q. (cont'd.) I'm using that term...would they then be covered by this guideline, they would be regarded as coming within the point two, or whatever, guideline? They would be counted...?

A. The situation is that if you have a nonfibrous amphibole such as riebeckite, and you grind it up, then there will be a large number of fragments which exceed the three-to-one aspect ratio. This is precisely why I, as an electroc microscopist say, would like to see a ten-to-one aspect ratio, because that, to some extent, removes the ambiguity between the fibrous and the nonfibrous versions.

Ten-to-one is an aspect ratio which very rarely occurs in a groundup riebeckite, but the three-to-ones do occur in groundup crocidolite, which is chemically the same.

So you are quite right, that groundup riebeckite will produce fragments which are going to be counted under any criterion we have.

Q. I believe I have one or two other questions.

In the paper you have given us this morning, Ontario Research Foundation, has that got an exhibit number?

MISS KAHN: Yes. We called it tab nineteen of exhibit twenty-six...

MR. McNAMEE: Tab nineteen...

MISS KAHN: Twenty-seven, sorry.

MR. McNAMEE: Q. ...of exhibit twenty-seven.

If you go to figure eight and figure nine, which are on page sixteen, if I recall your evidence this morning...have you got those, sir?

THE WITNESS: A. Oh, yes. Okay.

Q. If I recall your evidence this morning, you indicated that these were respirable fibers or respirable bundles?

A. It depends on how we are going to define

A. (cont'd.) respirable, but if we took the latest EPA recommendations on the topic, a ten micrometer unit density sphere would approximate to approximately eight point six microns...sorry, fifteen micron unit density sphere would approximate to about eight or nine micrometers, and this would, by that definition, fall into the respirable category.

Q. Do I understand that with some materials there is something called a size selector that you separate the respirable particles?

A. With some air samplers?

Q. Yes.

A. Well, there are a number of devices that you can use. The most popular one of the day is known as a dichotomous sampler, which is designed to separate the respirable from the nonrespirable.

The problem with this...well, let's put it this way. The earlier versions of size separators could involve these aggregates being impacted against a surface and releasing some of the attached material.

The dichotomous sampler blows a jet of air into a container and air is being pulled out by a tube which is exactly on the axis. The heavy stuff goes straight on down the first tube, and the lighter material follows the flow lines and goes around the outside of the tube and is exhaused through a separate filter. So you end up with two filters, one containing respirable and one containing nonrespirable.

Again, one has to be very careful about the definition of respirable at this point. That's an instrumental characteristic, and the instrument has to be carefully designed to reproduce what characteristics you want.

Q. The type of thing you are talking about, would it catch this type of bundle shown on figure eight?

A. I would suspect that that..as I say, by the

A. (cont'd.) definition of fifteen microns unit density, a device designed to separate the respirable component, this would end up in the respirable component fraction.

If the instrument was designed differently, it could be arranged that that did not go through the respirable fraction.

As I say, when we are in a situation where respirable diameter of particles has been thought of as being ten micrometers for so long, and then there is now a suspicion that we should be using fifteen, then the instruments will have to be redesigned to accommodate that.

Q. I have one last question. You have indicated that one of the deficiencies of the optical microscope is that it doesn't...you can't count the fibers below a certain diameter. Can you give any ratios...with the electron microscope you can obviously count almost every fiber...is there any ratio, are there any ratios you could give us with respect to, say a number of fibers, say ten fibers greater than five micrometers in length with a three-to-one aspect ratio were counted on a sample by optical microscope. Then it was put under the electron microscope and you count all the fibers, what kind of ratios are you getting? Ten to one?

A. That is dependent on the size distribution, of course...the actual work station. But we have seen numbers ranging from four to one, three not seen versus one seen by optical microscopy, to as high as fifty to one. This, again, varies with the size distribution that you happen to have.

Q. So the greater numbers, the greater ratios would be biased towards the smaller fibers, in the fifty to one that you found, and they are very small fibers? For instance, three to one might be found in the ones that are close to the resolution limit of the optical microscope?

A. The three to one would be where most of the

A. (cont'd.) fibers happened to be big ones, happened to be big diameters. In other words, in an operation where the large amount of asbestos was being used and where the majority of the material was still present as bundles, when the material is being broken down further, such as in a textile operation, then the fibers generally will be thinner. You would be seeing a smaller proportion of them by optical microscopy.

Q. Will you have any idea...you have indicated that between the mining of the asbestos and the eventual manufacturing of the asbestos pipe, or whatever, that these materials are broken down. Do you have any idea, say, that we have a mining operation where you have..just for example...say ten percent of the fibers are longer than five microns, and then that material is then processed into, say, asbestos pipe. Do you have any idea, would it broken down...say two percent of the fibers would be reduced to...you would have only say two percent of the fibers longer than five microns? Have you any ratios there?

A. Say that again. I didn't get the context of the asbestos pipe.

Q. You can obviously, from what you have said, you could take a sample at the mine and especially, say chrysotile fibers, and you could probably determine what percentage of... whether by mass or by number...are longer than five microns in length, or any particular length you choose. And you have indicated that these fibers, in all these processes of manufacturing, are broken down further by either crocidolite breaks down and also chrysotile breaks down into fibrils, smaller fibers, have you got any idea of the...maybe it is an awkward question..of the breakdown ratio or what...?

A. Not really. I think the best I could say is that any manipulation of the material is going to generate

A. (cont'd.) smaller fibers. And in the case of the asbestos cement industry, one is going to bring in other material which is going to be attached to fibers. So in other words, the material you find in an air sample is going to be material attached to pieces of cement.

MR. McNAMEE: Those are my questions. Thank you very much.

CROSS-EXAMINATION BY MR. SAMPSON

Q. I guess I would like to start out with sort of a general question to make sure I understand this notion of confidence limits. I noted in a couple of papers you...that were submitted...that you stress the need when reporting measurements, ambient measurements or water measurements or even workplace measurements, to include a distribution or a confidence limit.

Could you sort of elaborate on why that's important?

A. Yes. Well, the importance is where you are going to compare two numbers. If I have, say, five fibers per mil and six fibers per mil, I may want to demonstrate that five is actually a lower number than six. I may have calculated that they are, but in actual fact the next time I try and measure that five, I may get six, I may get seven. There is a spread of numbers which, depending on the sample that I'm counting, I may very well find that I can get a whole series of numbers. The average will be about five, but we need to express what is the probability, what is the range of numbers which I can have with that data that I have collected. What is the range of numbers which includes ninety-five percent of the measurements that I will make.

I can pick ninety-nine percent if I wish, but then the range gets bigger. So we normally pick ninety-five percent.

A. (cont'd.) In other words, there is only then a five percent chance, two-and-a-half percent chance that the value will be more than that, and a two-and-a-half percent chance that the value will be below that range. And so when we come to compare two numbers, we have to look at the way in which these ranges overlap each other. There are defined statistical tests to say is that number really lower, or is this just a consequence of my measuring technique.

Q. When you are comparing two numbers, that doesn't have to be two measurements, does it? You could be comparing a measurement against a standard or permissible limit of some kind?

A. Yes.

Q. And still have this problem?

A. Oh, yes.

Q. So that theoretically, just to throw out an example, if the standard is two fibers per c.c. and the variation is broad enough and I measured three fibers per c.c., I could still conclude that there is a more than five percent chance that I'm in compliance?

A. It depends which side of the fence you are on. If I am in the situation of the government where, before I take anyone to court I want to be sure, absolutely sure, as sure as I can be that they are out of compliance, then I would try to make sure that my lower confidence limit exceeded two.

And if I'm on the other side, I try to make sure that the upper confidence limit is below two.

In that way there is some guarantee, pretty well guarantee, or at least a certain degree of confidence that any amount of measurements would never prove anything different.

Q. I realize that your testimony goes mainly to the question of the precision of the measurement technique, but I was wondering in examining that issue whether you came across

Q. (cont'd.) any information indicating that, quite apart from the measurement technique itself, that the actual concentration, the dust cloud in a workplace, or the concentration of asbestos in the ambient air or in the water, itself, that concentration itself varies randomly, and that in other words there is some confidence limit that surrounds the concentration itself, wholly apart from imprecision in the measurement technique?

A. There obviously is, but this is the concept of using a personal sampler. The sample is taken to integrate what the worker has just been exposed to throughout the work shift.

Q. Throughout the day, but could there be variations between days?

A. Certainly, but that can only be determined by doing repeated measurements to get some feel for the extent of the variation.

Q. So the only way you would ever know that would be to really measure it continuously day after day after day?

A. That's the only way you would actually know, yes.

Q. Okay. Would that same sort of variation from day to day also apply in air concentrations and in water concentrations of asbestos fibers?

So that if you...I guess what I'm getting at is the idea of using grab samples or very short-term measurements to try to characterize what our exposure to asbestos in the air or in the water is. If there are wide variations, then that's also subject to some confidence bands, I would assume?

A. Certainly, and in that case you can only do it by many repeated measurements of the same source.

Q. Do you have any idea of how great a variation you are likely to see over a period of, say a year, in, let's take ambient air measurements at a single location, precisely

Q. (cont'd.) the same location, over a period of a year?

A. Not really. We've only got, as I say, a series of grab samples to look at in this context, but the Toronto subway numbers which were produced as a confirmation of some earlier work were entirely consistent with the earlier work, in that case.

We don't see, for example, a vast variation in the ambient air measurements we are making in buildings. We see them all down to a very, very low level. We just don't see... we don't go in one day and find them up by a factor of ten. This is all, you know, factors of two or three and well within the statistics of the actual counting.

Q. Okay. I think you said, I'm not sure I heard you correctly, in response to a question from Mr. Laskin, that you didn't feel as though it is possible to reliably measure, in the workplace, at a level of...I think you said point two fibers. Could you elaborate on that a little bit? Why...is this the same sort of statistical, inability to statistically differentiate from zero, that you were...

A. It's the same situation. If you have a detectible limit on your measurement of point one, then if I come along and make a measurement of point two, I put a confidence interval on that for my measurement, and I'll find that I'm going down below my detection level. So essentially I'm proving that the measurement I've just made is no different from my detection level.

Unless you can show that the measurement is statistically valid, then this is an unworkable level.

Q. How high do you have to get above point two before you reach a point where you do have a detectible, a standard that's feasible in the sense that it's detectible?

A. Well, I did respond, I believe, that I felt that one fiber per mil was a usable number. I would refer you to the AIA reference method for reference of asbestos, in which it's generally agreed there that the value, detection level rests somewhere between point one and point five. There is, in fact, some, perhaps some controversy over the actual value.

Q. You mention on page four of tab nineteen that, the statement you submitted today, the number of reasons for the variability in the optical microscopy method. You talk about instrument variation, at the top of page four there, operator subjectivity. Later down in the second full paragraph, variation between the competence and procedure between individual laboratories.

I wonder whether you could expand a little bit on what you mean by instrumental variation, what types of instruments do you see variations in, and where the most significant variations are?

A. As the methods are specified at the moment, there are a number of different methods, a number of different graticules being used in the microscopes...occupying a larger or smaller area of the total field of view, and you remember the comment that a phase contrast fiber count made over a full field of view generally turns in a lower answer than working with a repeated number of graticule areas in the center where the optics are better.

In those cases, one will be using worse optics in some areas of the larger graticules, so that is a difference between instruments being used essentially for the same measurement.

The other thing is that the quality of objective lenses is really a function of how much you are prepared to pay for them. If you go and buy a Zeis objective lens, you will find it will cost you a lot more than a Bausch and Lomb objective lens. There is a reason for that, and the

A. (cont'd.) reason is that the optics of the Zeis lens will be substantially better than the Bausch and Lomb for this purpose.

There are...and I'm not going to pick names here, but the situation is that specific objectives...in fact you will find it referred to in the AIA method, that even microscopes of the same manufacture, there are good microscopes and bad microscopes for doing this particular job, and attempts are being made to standardize what is being used.

At least if we can say, you buy a Zeis model such-and-such with this particular objective lens, and if eventually we begin to get some standards built-in, standards to calibrate or to establish that we really can see a point two micron fiber of chrysotile, that's the important thing, to determine that your visual acuity on the microscope is really what you think it is or what the method says it is. At the moment there is no such standard sample to use.

Attempts are being made on this, but as I say, they are not generally available at the moment. That is an instrumental variation.

Q. Would there be any, in your experience, any instrumental variations at the sampling stage in the workplace context? For example, would the sampling pump be something that might be susceptible to imperfect performance from one day to the next, that might play a role in the total variability of the method?

A. Certainly, but the point about this is that with a counting error that we have, then a ten percent or five percent error in the total volume sampled is really rather minor. We don't normally consider that we are making major errors in the volume of air sampled.

I think provided the things are being used as the method says they should be used, then we shouldn't encounter

A. (cont'd.) any errors of that type.

Q. So what you are saying is, you...I can't find it just paging through your statement...but you mentioned this morning that fiber counts were differing by a factor of six in one study. Those difference or those variations are purely fiber counting or fiber identification differences that don't take account of additional instrument problems such as sampling pumps and things like that?

A. Yes, because these were sectors of the same filter.

Q. These were...were these experienced counters that were involved in that?

A. Yes.

Q. So that would be a minimum variation that you might find in a method? The method may vary by even greater margins than that if there are other variations that weren't tested in that particular interlaboratory experiment.

Is there any estimate available of the total variability of the method from beginning to end?

A. You may find that in the AIA document. I'm not sure.

Q. If you did know the variability of the method from beginning to end, would that help you define the confidence limits around a particular measurement?

A. I don't think so, because we are measuring here, we are making a measurement of the number of fibers on the filter, and if we...it is easy enough to buildin potential error from another source. The major error is always in this counting procedure. The...first of all your statistical errors cannot be avoided unless you count lots of fibers. To get even within fifteen or twenty percent you really have to be counting in excess of a hundred fibers. If you count anything lower than that, the confidence interval just gets bigger and bigger.

Q. Do all these potential sources of variation we are talking about, counting difficulties, instrumentation variations and things like that, do they also apply when using electron microscopes and sampling?

A. Well, not quite. We have no limit of visibility problem. If there is a fiber there, you see it. There is no question about that.

The problem in the workplace atmosphere, using electron microscopy, I don't think there really is a problem because we largely know that the material that's fibrous on the sample is going to be asbestos.

The problem with electron microscopy comes when we are trying to do a measurement in the ambient air. So if someone gives me a sample from a downtown Toronto location and says, is there asbestos in here, if we find any fibers then it is an identification problem. That is where the expense of this procedure comes.

Q. Is that where you would also see some variation that you wouldn't see in the optical microscopy context?

In other words, does that produce an additional degree of difficulty in the case of the electron microscopist who is trying to do his job that may add another degree of variability in that case?

A. Well, of course, at one time it was either... the actual preparation methods for the electron microscope were not very good. That has now been fixed. The preparation methods now are really very good.

Variability in sample preparation used to be one of the major discrepancies. We don't have sample preparation problems for the transmission microscope now.

The main source of variability may be our ability to identify the fibers, but what we have instituted now is a fiber classification scheme in which the operator says what he

A. (cont'd.) did to identify each fiber. That was certainly not recorded data in the past, and we have expanded this.

The question crops up as to what we are going to define as asbestos, and we take three-to-one aspect ratio still, we take a fiber and really do a very detailed crystallographic identification of it nowadays. But it's too expensive to do that on everything. There have to be some shortcuts.

Q. That's the analysis that you mentioned before would cost four hundred and fifty to five hundred dollars?

A. No. That would be closer to two thousand. We are talking here in the routine analysis of identifying the chemistry and...the chemistry of the fiber combined with perhaps some indications of its crystallography. If you want precise crystallography work done, it is a very time consuming business and you can spend two hours or so on a single fiber, involving a number of computer analyses afterwards. We are doing this quite regularly and have it down to a fine art, but it is not an easy job.

Q. It doesn't sound like the kind of thing you want to have a routine monitoring program for.

DR. UFFEN: Could I insert a little question in here?

MR. SAMPSON: Please do.

DR. UFFEN: In the actual collection in the membrane filter of the sample, can anybody monkey with the thing? Is it covered up so that it is supposed to be collecting dust for eight hours and only collect it for two?

THE WITNESS: Certainly. You can switch the pump off. If he was to just put something over the front, then presumably it would just...it's measuring airflow, so presumably it just wouldn't add up enough on the register of total volume. But I'm not quite sure what the procedure would be. Certainly our

THE WITNESS: (cont'd.) pumps have a total integrated flow, which is the number of revolutions of the pump. But it also has a flow meter on the side, as well.

DR. UFFEN: You would know if the pump got shut off? Would you have an independent method of determining whether that had been monkeyed with? Is there any way of being sure that it hasn't been monkeyed with while the pumps still were operating?

THE WITNESS: In what way?

DR. UFFEN: Covered over?

THE WITNESS: Oh, you mean cover it over while... with what intention?

DR. UFFEN: To cheat.

THE WITNESS: You mean to bring the numbers down?

DR. UFFEN: Yes.

MR. BAZIN: Or the reverse, put more on.

DR. UFFEN: Or blow into it...

THE WITNESS: Oh, of course it could.

DR. UFFEN: Yes, one way or the other?

THE WITNESS: Yes, of course. It's an open filter face.

DR. UFFEN: So that the present system has to be operated properly with no human foibles...

THE WITNESS: With some good will from the person using the sampler, yes.

DR. UFFEN: Right.

MR. SAMPSON: Q. Okay, this isn't going to be easy to do, but I'm going to try.

What I'm trying to get into is paragraph or section two-six of your statement today, which is tab nineteen.

DR. DUPRE: What page?

MR. SAMPSON: Page twelve.

MR. SAMPSON: Q. You say in here, "Use of an

Q. (cont'd.) "intermediate value standard between those for the two types would be unsatisfactory on a plant-wide basis".

What do you mean by an intermediate value standard? Would that be sort of a weighted average of the two, or an average of the two standards?

THE WITNESS: A. Well, you could think of a weighted average or an average of the two standards. If someone is using fifty percent chrysotile and fifty percent crocidolite, you could conceivably say well, maybe we had better apply a standard halfway between the point two and the one fiber per mil, whatever we are going to be using for the two different materials.

Q. What do you see as the disadvantage of doing that?

A. I'm sorry?

Q. What do you see as the problem with doing that sort of thing?

A. The problem I see is that the individual who is receiving and manipulating the pure crocidolite in part of the plant is in fact receiving...is in fact having the wrong standard applied to him.

Q. What if...and this is where it starts to get difficult...but what if you allowed an employer, in effect, to establish...if the government established standards sort of on a guideline basis...let's say one fiber per c.c. for chrysotile, and point two for crocidolite, just to take an example...what if the government allowed employers on an operation-by-operation basis to adopt or to comply with these intermediate value standards, as you call them, so that he would account for the situation where you have one operation where the worker is in fact dumping pure crocidolite fibers into a bin or something, and deserves the protection of the more stringent standard, but in another operation where there is mixed exposure to the two fiber

Q. (cont'd.) types, you would have an intermediate standard that reflected the relative weight or contribution of the two fiber types involved in that particular operation?

Did that come out clearly?

A. Yes. I don't think it would be terribly satisfactory, because one is not in the position to say what the airborne cloud is. We do not have any identification going on here.

A quote from the British Columbia regulations, which were introduced effective October, 1979, in which in a mixed environment they defined the particles, the actual airborne material, by bulk sample of material, using polarized light microscopy, x-ray diffraction or electron microscopy, and then they applied the lowest standard. In other words, if you were operating in an operation with chrysotile and crocidolite there, they would be applying point two to the whole operation.

Q. Even if the crocidolite was point zero one percent of the total exposure?

A. Well, I guess that's the purpose of the bulk examination, and presumably there they have some minimum concentration at which they would start applying that kind of argument.

Q. Would it be any more satisfactory if you were to say that an employer could...rather than simply assume that the airborne concentration reflected the percentage of various fiber types in the material being processed in a given operation, that the plant owner could, in effect, demonstrate...say by use of electron microscopy...that a fairly stable relative concentration of the two types of fibers was present in the air for that operation, and then having established that, set up a sort of intermediate value standard again using the term you've used, on that basis?

A. It depends how stable the airborne dust cloud could be. The point you made earlier that there may be a variability here which we can't measure unless we measure it all the time would then suggest that we would have to do electron microscopy all the time, on every day, and that's not feasible.

Q. I'm asking the question assuming we don't have all these measurement difficulties, and that we have a technique that has a detection limit that we can deal with at these levels.

MR. SAMPSON: Okay, I think that's it for me.

DR. DUPRE: Is this an appropriate moment to take a ten minute break?

MR. LASKIN: I think so.

THE INQUIRY RECESSED

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THE INQUIRY RESUMED

MISS JOLLEY: I do feel a little out of my depth, but I'm going to try and wander into these waters that you presented this morning.

CROSS-EXAMINATION BY MISS JOLLEY

Q. I want to just go over a number of the things that you said this morning so that I understand them, and therefore I then want to reach a conclusion.

I think in your discussion with Mr. Sampson you suggested first of all that there is a possibility of variability happening in the actual sample taking on the plant floor. We are just talking about occupational exposures now...or I am.

Then you have a situation where you are using a phase contrast microscope which is a nonspecific kind of tool and you don't know what you are measuring there, you are assuming

Q. (cont'd.) it's asbestos, but the phase contrast microscope can't tell you that. I mean it can tell you it's a fiber, is what you told us this morning, is that correct?

A. Yes.

Q. Then you have a situation where you defined a fiber as an aspect ratio of three-to-one, and in one of your papers you said that that was a purely arbitrary figure selected in the U.K.?

A. Yes.

Q. And you suggested perhaps that we move to ratio aspect of ten-to-one, but one might also move downwards and the ten-to-one, your suggestion, may I ask you a question there?

Is there any biological significance of moving to ten-to-one, or is that just purely for more reliability in counting?

A. You would find that there are some analysts who would support...sorry, I beg your pardon...some biologists would support the idea that a ten-to-one aspect ratio is going to be more toxic than a three-to-one. The problem is that the original suggestion of the ten-to-one aspect ratio change comes about because we are not able at the electron microscope level to discriminate between the fibrous and nonfibrous particles.

In other words, if we have a sample of crocidolite, then there is always some proportion of that crocidolite that is in a nonfibrous form. That's the riebeckite which was around the crocidolite when it was mined.

This, unfortunately, we are not in a position to discriminate between the two, so you can find yourself going into a mine where fibrous crocidolite doesn't exist, but riebeckite does exist when we are mining some other material.

For example, there are gold mines in which grunerite exists. Grunerite is the nonfibrous form of amosite,

A. (cont'd.) As far as the electron microscope is concerned, we are not able to discriminate between the two.

So the ten-to-one aspect ratio was suggested at that time to allow us more reliably to count, or to account for, the fibrous components, rather than to suddenly find we have to start applying asbestos regulations to a thing like a gold mine where there is no evidence of any asbestos presence at all.

In other words, what I'm saying, you can have a hand sample of rock which is quite obviously nonfibrous. You can have another hand sample which is fibrous, and we are not able to tell the difference when it's single particles.

Q. And we don't know that yet, or it's debatable, as to whether those particles, rather than fibrous, are biologically active?

A. We don't, no.

Q. All right. Okay. That's another variability involved there.

Then you have the five microns in length, which you concluded in one of your papers ...sorry, tab thirteen...that it bears no relationship to epidemiology or experimental evidence, it's just...the five microns is there because of the technique, not because of any scientific...

A. It has been an arbitrary selection.

Q. Then we get into the issue of whether you are actually measuring what's biologically active then, and on page...tab thirteen, page one-sixteen, you concluded that,

> "It is becoming clear that the fibers measured using the legislated membrane filter method do not include those having dimensions strongly correlated with high tumor production in experimental animals, and which also form the majority found in the lungs of mesothelioma patients."

Q. (cont'd.) So we have all of these variabilities and we aren't even measuring what is causing the disease.

Then you have in tab eighteen, page nine, which was your presentation to us back in ...I've forgotten...

A. December.

Q. December, right. You suggested that...on page nine, as I say..."In many airborne distributions the phase

> contrast optical microscope measurement records only two to twenty-five percent of the fibers longer than five microns, and perhaps only point one to one percent of the total number of fibers."

So we are not even measuring what may be the biologically active...and there's a huge number of other fibers that may be biologically active that we are not measuring.

Then we have the situation of the reader, the variability between readers, of a level of six, and you might have Friday afternoon versus Monday morning situations.

And then we have a situation of time weighted averages for workplaces over forty hours, taking grab sampling here and there where you are evening out peaks, and can you give the workers in the Province of Ontario any confidence that you have measured anything that has anything to do with their health?

A. That's an interesting question. I think the phase contrast method should be regarded as a very simple test in order to...which is used in order to control the dust in workplace atmospheres, and in order to assess whether or not any improvement is being made as a result of certain control measures. And indeed, control measures certainly as far as Environment Canada are concerned, on emissions to the atmosphere, are made on the basis of forcing the best available technology.

A. (cont'd.) In other words, we have fiber counts controlled the emission point from a plant into the atmosphere, based on phase contrast microscopy at two fibers per milliliter longer than five micrometers. That is a very stringent control, and what we are saying there is, that is a legislated number which forces the use of the best available technology in the plant.

Now, when it comes to looking at the exposure of the workers, the same situation applies, that one is able to apply good technology and to bring down the fiber levels by a simple measurement technique.

I personally would rather see a lot of measurements by a simple technique, because of this fundamental variability problem, than I would see a single measurement made at one work station being used to define everything, of a much more sophisticated nature.

So here we have a situation where we are saying we take a number of measurements and those are the things on which the overall dust loading in the atmosphere of the workplace is controlled by. What I would contest personally would be whether or not these can be related to epidemiology in any meaningful way, in view of the fact that there have been improvement of methods over the past few years...the factor of six that you are referring to would certainly have been much worse a long time ago...and in addition we have been bringing down the levels and also changing the size distribution.

So the question of whether you can relate the epidemiology in a meaningful way when there has been this amount of variation, is an open one. But as a dust control measure, I think it's a perfectly reasonable way of approaching the problem.

Q. But then you said to us this morning, and you've just mentioned it again, is that when you institute control technology you are in fact changing the dust cloud

Q. (cont'd.) dimensions. What we are getting, for instance, as asbestos workers now, are probably much smaller, thinner fibers because of the two fiber standard in Ontario, and the technology that went along with that. Is that correct?

I mean, we may be getting...

A. Not necessarily getting more thin fibers. What they are getting are the same thin fibers they always got, but the big ones are not there anymore.

Q. Right, but small ones are?

A. I'm sure they must be.

Q. And the small, thin fibers are the ones that the biological evidence indicates to us are still the health hazard.

A. The small, long fibers appear to be the ones on a single fiber basis, that give the health hazard, yes.

Q. You say the small, long, but there is also evidence that the small, short, thin...thin, short ones can, because of the huge number of them, also be biologically active?

A. Yes.

Q. So we still have, even though we may be...

A. There are arguments for and against, as you are well aware, and it is likely that control measures have left the small, thin fibers still airborne. They are not measured routinely. I am quite sure some measurements may have been made, but any control measure will selectively take out the big ones.

Q. Can I ask you a question, because I was a little confused back in December...and I've reread the testimony and I'm afraid it hasn't cleared up...and we were talking about the costs today of electron microscopy, and that if you have to identify the asbestos, it might cost four hundred to five hundred dollars per sample. What about in a workplace situation where you don't have to identify, as you said, where it's a simple

Q. (cont'd.) operation of just merely counting them. What kind of sampling cost is that?

A. Well, if I was asked to say...let me put it another way...if I was asked to say what form of electron microscopy would be appropriate at a reasonable cost, for the workplace atmosphere, I would say a scanning electron microscope.

The samples could be put through a scanning microscope, I would say probably at close to the same price or close to the same labour that is required now. It is a capital equipment, is the problem.

We are not doing identification, we are merely counting fibers. The SEM gives far less of a problem to the operator in terms of fatigue.

Q. You mentioned that the actual scanning electron microscope would be about eighty thousand dollars?

A. I would think so. You wouldn't get one much cheaper than that.

Q. Then you have a computer attached to that. Does the computer actually do the reading? Could you replace the reader as well?

A. You could replace the operator with a computer.

Q. I shouldn't be encouraging that.

So essentially an eighty thousand dollar investment, plus the reader.

How many scanning electron microscopes are there in the Province of Ontario?

A. Rather a lot. I don't know that I would want to put a number on it. It would have to be between fifty and a hundred, I would think. I really can't put an absolute number on that. There are probably ten or twelve I could put names to in this area alone.

Q. If we maintain the Ontario proposed standards

Q. (cont'd.) and used a scanning electron microscope, they would be very tough standards to meet, is that correct?

A. Well, again, it depends on how close to the existing level we are, but I would imagine that workplace counts done on the scanning microscope would be significantly higher than the workplace standards done by phase contrast microscopy.

Q. I don't know if I should venture into this one, but it was about your magnetic alignment. You have indicated to us that you are measuring mean diameter and mean length. How would you set a standard for your new technology?

A. Well, of course, in this case one could set a standard by having a sealed ampule of a known distribution. Rather like we nowadays define the unit of length. We have a thing which is called a standard meter, and everybody takes their measurements from that. So we are in a position now to have a stable dispersion of asbestos fibers in liquid, which could be sealed and which could be used as a basic reference standard for everyone to use. Successive standards could be calibrated against that particular standard.

So this is one of the reasons I bring this method up is that it does have the possibility of having a fundamental standard kept at Queen's Park, or somewhere, which is the basis for all measurements.

In the case of the proposed Ontario method, it is in fact very largely a method which is slightly modified NIOSH method. Even the slides cannot be retained for storage. I think one of the basic problems with this kind of work is that one would like to keep the slides for future reference if possible. Then you can give the same slide to someone else and say, hey, you count them. At least there is a permanent record kept of some kind.

Using the AIA method, certainly there is...it is a permanent slide mount and these things have been demonstrated to

A. (cont'd.) be stable for some years.

But the basic problem is that of standards. It would be nice to refer everything to a known number, which unfortunately at the moment, it is not being done.

Q. There is...the one thing..the two other questions I would like to get into, and that is that you showed us this morning slides of building atmospheres that you took, that were largely vermiculite?

I'm sorry, that's not true. They were largely gypsum. Is that correct? I think what...I'm not sure what I'm trying to get here...if the physical parameters are the dominant thing involved in physiology or in biological reactions to these fibers, and we've had evidence from Stanton that in fact fiberglass, or glass fibers, of a very small diameter and proper length will in fact induce a cancer in rats. Is it possible that these other things could be doing that as well, if they meet those...?

A. It would be entirely possible, but one would have to look at the incidence of disease in the gypsum industry, which I'm not familiar with. I have certainly not heard of it.

Q. Okay. The last question I have, and this is not from you exactly, but it is something that you report on. That is, that the State of Connecticut has set an ambient air standard, and they set an ambient air standard of thirty nanograms per meter cubed, which is stated to be equivalent to thirty thousand total fibers per cubic meter.

Then there is an interesting statement at the end, and I just wondered if you can comment on it. But it says,

> "This standard was developed by extrapolation of the mesothelioma incidence among asbestos workers"...I'm sorry, page one-thirteen...."and assuming an incidence in the general population of the United States of a hundred and fifty cases per annum to be acceptable..."

Q. (cont'd.) Do you know how they came to that conclusion that a hundred and fifty cases a year of mesothelioma is acceptable?

A. Their intention, this was the...I can't remember the authors' names now...Rubino, I think is involved...

Q. Bruckman is the...

A. Bruckman, sorry.

Q. Right.

A. If you get the Bruckman paper, you will see that his philosophy has been that we need to establish an ambient air standard, and what would be a suitable number to introduce.

He has in fact, I believe, taken certain other infrequent things like deaths through aircraft accidents and things like this, and just picked on a number and said now, supposing we take the asbestos workers' mesothelioma incidence and plot incidence versus fibers, then you get a very difficult curve to interpret. He has just done an extrapolation of that in order to arrive at thirty nanograms per cubic meter.

As a matter of fact, there may even be some errors in the calculation. I think his number of fibers per gram is not correct.

Q. I just find the whole acceptability situation very difficult to deal with.

MISS JOLLEY: Thank you very much, Dr. Chatfield.

DR. DUPRE: Thank you, Miss Jolley.

Mr. Bazin?

MR. BAZIN: It will be short and sweet, Mr. Chairman.

CROSS-EXAMINATION BY MR. BAZIN

Q. Dr. Chatfield, you mentioned that you would prefer, at the workplace, lots of measurements with simple equipment. Can you elaborate on that?

A. I think it's the same situation as we found in the Bowmanville High School when we were examining the insulation samples. You could pick out a single sample from the insulation at Bowmanville and draw the conclusion that you strip out all of the insulation, or you could have picked another sample and say there is nothing in this school. There was a mixed situation.

I think the dust cloud inside asbestos plants is much the same. If you take a sample in one location, it's going to be different from another, and there's a time difference as well. This is changing all the time.

So it would seem to me that you get more information on actions to take by spreading your measurements over a larger time period and over a larger area of the plant. My philosophy there is, obviously, that we would like to see very sophisticated and expensive measurements made in that way, but there are financial constraints.

I think the larger number of samples..if the errors in the individual measurements are very large, then a larger number of samples allows you to get data which permits decisions to be made more effectively. You have the standard deviation of the entire group of samples coming down the more you take, even though the individual measurements are not particularly reliable.

Q. Which would seem to infer that at the workplace gravimetric measures are the types of measures which you would favour?

A. Gravimetric method has its place. Unfortunately, we do have a worldwide tendency to use fiber counting. In other words, every country I am aware of has used fiber counting as their standard reference method.

Q. On the question of the samples, just to be precise, how are the samples carried to your lab? Could that be a factor to change some of the results, the actual transportation, quote, unquote, of the samples?

A. With the millipore filter, the conventional filter used for this measurement, I don't think there is any major problem there.

There is a problem with using nuclepore filters for ambient air samples. They do have to be handcarried. Otherwise material is going to be moved on the surface, or lost. That has been one of the major criticisms I have made of the U.S. EPA method for ambient atmospheres, that they recommend a filter, recommend a method, and you virtually have to handcarry the filters right way up and make sure that it's not damaged in any way enroute.

In the case of millipore filters, I don't think that is a problem.

Q. You said that you didn't think it was a major problem, and now you are saying there is no problem with that type of filter?

A. It would depend on the loading of the filters, and the filter as loaded normally for a workplace fiber count, there would be no problem.

Q. You have conducted testings in various schools, I understand, here in Ontario, have you?

A. Yes.

Q. Is it my understanding that it was done inside the school and outside the school?

A. The reason for doing it outside of the school is that at the time when we had teachers going on strike at various points because of the hazard of the building environment, that we had no basis for comparison. We received, as an analytical laboratory, we received a lot of pressure to make measurements of this kind, but at that time neither the Ministry of Labour nor the Ministry of the Environment had a standard other than the Ministry of the Environment point zero four.

We had to provide information in a report which

A. (cont'd.) said, we have done the sampling, and then we had to comment on the results, because the reason why the samples were being collected was to convince the population inside the building that the atmosphere was safe.

It seemed to us at the time that the best way of dealing with this was to demonstrate that the building atmosphere was no different from the atmosphere outside...lacking any suitable standards.

Later on we began to build in to the discussion the Ministry of Labour standards and the point zero four guideline of the Ministry of the Environment, quoting the only known standards that we have.

Q. These measurements did indicate about the same thing inside and outside the building, is that correct?

A. We have not come across cases that the inside has been higher than the outside.

MR. BAZIN: Thank you very much.

DR. DUPRE: Dr. Uffen?

DR. UFFEN: I have three questions to put to you, which may be disposed of very quickly.

In the membrane filter method and the filters themselves have to be eliminated when looking through the microscope so they treat it with a liquid of the correct refractive index, which happens to be too close to that for chrysotile and its hardly readable.

Is there no other filter material so that instead of ending up with the problem, you use another filter material which requires a fluid of a different refractive index?

THE WITNESS: Well, in fact if you put the question that way, there is a filter material in which one wouldn't have to use any refractive index medium at all. If you get a copy of the report published by the Battelle Memorial Institute on Analysis of Water Samples, A Rapid Survey Method for Analysis of

THE WITNESS: (cont'd.) Water Samples, you find that the technique described there, in which sampling was carried out on a nuclepore filter, or where the fibers are on the surface of the filter, the filter was then coated with a very thick layer of carbon to make it reflective, and it has the added advantage of expanding the diameter of the fibers so that they become optically visible even at the single fibril diameter, chrysotile. These samples were then looked at by reflection microscopy.

This seemed to be a very workable technique.

DR. UFFEN: Why don't they use it then?

THE WITNESS: I don't know.

DR. UFFEN: Another one that has puzzled me, the minerologists' polarizing microscope is used to look at an overall...I have forgotten, or never did understand, why can't they use a petrographer's microscope and use polarized light and distinguish between the different fibers by their coloring under polarized light?

THE WITNESS: Well, first of all the chrysotile would be too small. You would have no interference columns.

DR. UFFEN: Oh, all right. Thank you.

Can I make a big switch, it's the end of the day, I don't want to make it unpleasant. Yesterday we had a long, interesting discussion between Mr. Lemen and others about a gold mine that had been examined. Are you familiar with the controversy...?

THE WITNESS: I am familiar with the controversy, yes.

DR. UFFEN: Between the McDonald paper and the Lemen paper. Is there any possibility that the discrepancy could be explained in any way by the counting procedures used?

THE WITNESS: Were any counting procedures used? Because this is an epidemiology study on miners in the Home State

THE WITNESS: (cont'd.) Mine, gold mine, where grunerite was the species under consideration. Was any quantitative work done?

DR. UFFEN: No, I guess they didn't give the results in terms of response...there was a lot of discussion about whether the grunerite was ground up, did it make any difference. Perhaps I've worded the question wrong.

Would you like to...?

MR. LASKIN: I don't know if I can do it, but as I recall the paper the only counts they did were 1974, which was after the period of study, and they tried to take some counts at that time and suggest that they may have been the kinds of situations they saw earlier. But I think the study itself, the record will demonstrate what it is, was based on terms of years of exposure as the index of dose. But at the same time, there must have been some assessment of the silica level, because as I recall that was critical to the assessment that they demonstrated that the silica levels were not any higher than other mines, and therefore they drew the conclusion that the only one that wasn't accounted for was asbestiform. As best I recall it.

DR. UFFEN: It left unanswered the question of whether the mineral was in its fibrous form or not, or not being in its fibrous form it got ground up in the milling process in the mining.

Can you offer us any assessments on the controversy?

THE WITNESS: The only assessment I've made, I made before I ever came here. That is that the...if one is doing epidemiology, I feel that one should be comparing the exposed population against some kind of control population, and the difficulty here seems to be a case that one study studied just a group of miners, underground miners, and the other study included a lot of other people in the exposed population. The results are

THE WITNESS: (cont'd.) going to be...the results are probably statistically rather difficult anyway, and you could swing the result by just changing the population.

That was my personal opinion before I came here.

DR. UFFEN: Now another real wild excursion. You pointed out quite clearly here that sooner or later we are going to need ambient air standards, and you've drawn careful attention to this.

Is there any possibility of using your techniques that you have developed for water, go up into the Arctic, get a slice of an old glacier right down back several hundred thousand years, take the samples back and get an historical record of what the air was like?

THE WITNESS: That would be possible.

I think it would because the presence of the asbestos in our environment has been referred to as very largely coming from man's activities. I am so sure that that's true. It may have been there all the time, and may have been there circulating for many millions of years, and we may be seeing a fundamental background which is nothing to do with our mining activities at all, or our use of asbestos.

Certainly in the urban environment, okay, there are going to be levels above that because we are using brake linings and we are using asbestos, but in rural situations you still find it. I found asbestos in virtually every sample we brought back.

DR. DUPRE: Dr. Mustard?

DR. MUSTARD: I would like to take you to a pattern of reasoning which sort of is my response to your course for us today. We have been coming at this with people, sort of the gross disclosure that dust and asbestos seem to be bad for you, the epidemiologists trying their best to get some kind of measurement of dose against response and then trying to refine it with all kinds of fancy conclusions. But obviously, as we are

DR. MUSTARD: (cont'd.) all aware, there is an enormous problem. That is that they are base line measurement of what people are actually exposed to has all kinds of ifs, ands and buts in it.

It seems to be in what you have said today, particularly this afternoon, as I understand it, you could take the modern technology that is being developed and use that, as Dr. Uffen said, as the base line standard for fibers from which you could then standardize simpler techniques.

Now I guess my first question is, how long before we will do that? It seems to me that you've got this stuff coming on line. Is it going to be ten years, two years, one year?

THE WITNESS: Well, as far as the actual standards themselves, the standard dispersions which are stable, we already have those and we are in fact already passing some of those to the National Bureau of Standards in New York.

DR. MUSTARD: Those standards are using electron microscopy, are they?

THE WITNESS: Yes.

DR. MUSTARD: So then you can now put those into your instrumentation?

THE WITNESS: Yes.

DR. MUSTARD: So it should be, therefore, possible to fairly quickly develop standardized assay systems in which each level of the assay, from the sophisticated to the simple, can be set forth in a matter which would have some degree of precision and also a clear definition of its limitations?

THE WITNESS: Yes.

DR. MUSTARD: I guess my question is, are we going to take two years to do that or can we do it a little more rapidly, because I think it would answer a whole series of questions in terms of what kind of regulatory levels you set

DR. MUSTARD: (cont'd.) if one could get this standardization system developed.

Do you have some idea as to how long you think it would take?

THE WITNESS: That could be done quite rapidly. We have the equipment already. We have some standards which we have already prepared and are properly characterized. The question will be, I think, whether we can accurately reproduce the airborne distribution that we have in the workplace...in the liquid standard. A liquid standard is by far the most appropriate thing at this point, because that fits the instrumentation.

Portions of that liquid standard then can be used by normal techniques to prepare filters for counting. So there seems to be, I would say, there is a way of approaching this thing.

I don't think it need be on the two-year level.

DR. MUSTARD: Now to follow up to that, has anyone using the modern technology gone into a mine and sampled it to find out what the true fiber characteristics are in the atmosphere in the mine, gone to a milling area and done the same thing, and gone into the other processing plants like textiles, and also done the same thing? Has anybody systematically now tried the modern technology against that so we really know what the fibers are like, their distribution, etc.?

THE WITNESS: I think Graham Gibson has done it.

DR. MUSTARD: He has done all that?

THE WITNESS: I think he has done some of that.

DR. MUSTARD: Is that all published?

THE WITNESS: Again, I wouldn't know. Some of it is.

DR. MUSTARD: Because it would seem to me that is kind of a fundamental thing that should be done, to clear

DR. MUSTARD: (cont'd.) up all kinds of ifs, ands and buts in the system.

THE WITNESS: Yes, certainly.

DR. MUSTARD: That leads me to my third question. Has anybody taken buildings with asbestos in them and tried the modern technology of assessment, the sophisticated technology of assessment, in terms of what really is in the atmosphere of the schools (a) in a spreaded condition when kids play basketball in gymnasia with asbestos on the ceiling, or when workmen go up into the area where the asbestos is on metal, and is there documentation of what actually does appear in the atmosphere under these different conditions, the resting state and with a bit of activity? Has that been done? Have you done that?

THE WITNESS: We have obviously done some parts of this, because we have some data on school atmospheres, but we will be doing some more during the next...

DR. MUSTARD: Do you have it really sort of using the very refined techniques that you can look, you've got a swarm of fibers of this kind, some that you would never pick up on the standard optical system, electron microscope, that you can say you've got two billion fibers in the atmosphere and for teachers to go and hide yourselves, or we've got two thousand and...

THE WITNESS: No.

DR. MUSTARD: Has this been done?

THE WITNESS: We don't have it on that scale.

DR. MUSTARD: Nobody has done that?

THE WITNESS: No.

DR. MUSTARD: But you could do it?

THE WITNESS: Oh, yes.

DR. MUSTARD: Wouldn't that make it a lot easier to sort of resolve whether you sort of strip all the stuff out of schools, or what you do, if you had that information? Wouldn't we be talking from a firmer base line in this sort of procedure?

THE WITNESS: I'm sure we would. As I say, our information at this time is that at the levels of point zero zero four fibers per mil longer than five microns, we are not able to see any change when insulation is torn out. The measurements we have so far would indicate that...well, the statistics are the same.

MR. LASKIN: Point zero four?

THE WITNESS: No, I said working at the levels of point two noughts four. In other words, working to a senstivity of point two noughts four, our results are almost invariably less than point nought nought four longer than five.

DR. MUSTARD: My final point on this one is, some of you may have noticed after lunch I wasn't eating Lifesavers to stay awake, I was reading this little book...but one of the things that fascinates me is a book, I don't know whether, counsel, I can refer to this book, but I will anyway, it's The Biological Effects of General Fibers, Volume One, which I'm sure is World Health Organization, 1980.

It's a fascinating book because it goes through all the animal experimentation, the different kinds of fibers, and I've already asked our witness a question, but I would like to ask him simply for the record, because I think it raises an interesting point. They are using supposedly standardized fiber material in all of these studies. It occurred to me that if they are doing that in the animal biological experimentation, including working with simple cellular systems in tissue culture, that some very important questions can be answered there which relate to the fiber-size/type question on the composition of the fiber, etc., and if that work with the standardization of fibers there could be done against your other fiber standardization, it would make a very powerful tool for that next stage in our development.

I was going to ask you the question, do you know if anybody has tried to look at the modern technology and set up

DR. MUSTARD: (cont'd.) for fiber identification in the real world versus the standardized fibers that are being done here, to see if one can get the cross correlations?

THE WITNESS: The only thing I can say in answer to that is that there is as a consequence of the UICC materials, which were originally prepared for animal work, as a consequence of the fact that we are nearly at the end of those, it's nearly all gone, the U.S. government, I believe it was jointly between the National Cancer Institute and one other agency, decided they would commission preparation of a large amount of well-characterized material, including some of the materials from the Reserve Mining location in order to characterize this material adequately for feeding studies and inhalation studies, and that material has in fact gone through some kind of sophisticated characterization.

DR. MUSTARD: That could also then be used as a base reference material for standardization of a new system for assay?

THE WITNESS: Yes.

DR. MUSTARD: So that one could then say biologically we know that these fibers do this...

THE WITNESS: Yes.

DR. MUSTARD: ...we've got this type of fiber in the atmosphere. From that you could then draw or arrive at conclusions for the future?

THE WITNESS: Yes.

DR. MUSTARD: Is that going to take ten years or two years?

THE WITNESS: I don't know. With the Reagan cuts, of course, some of these programs have been stopped.

DR. DUPRE: One question, Dr. Chatfield, I want to go back again to a very interesting point you make about the

DR. DUPRE: (cont'd.) proposed Ontario standards. Of course I've established there that your comments which are on paragraph two-sixty, page twelve, are all cast under the assumption that it is phase contrast optical microscopy that is being used.

THE WITNESS: Yes.

DR. DUPRE: If instead we go to scanning electron microscopy, is the problem that you have identified there overcome?

THE WITNESS: In two point six, with scanning electron microscopy, one would be able to work at the levels quoted and produce a separate tabulation of the amphibole versus the chrysotile fibers. So you could apply whatever standard you wished to, depending on the mix that you got. That would come out in each sample.

DR. DUPRE: Is that the only alternative technology at the moment that is available that will make the standard feasible, or standards such as this feasible, or are there others?

THE WITNESS: It has been a common thing to try to use dispersion staining microscopy as a means of separating these two, but unfortunately, you can in fact do an identification on a fiber using that technique. We use it quite regularly, but it's a technique which only works on very large fibers. The conditions under which you use it are not those in which you expect to get visibility and contrast in fibers. You immerse a fiber in a liquid which is almost the same refractive index and then you stop down the condenser lens in such a manner that the resolution is really very bad. You are looking for changes of colour and we are not being able to assess the size of fibers.

Consequently, that's the only optical technique I am aware of. One would, perhaps, be able to vary the refractive index so that at times you can see the crocidolite and at times you can see the chrysotile, but the refractive index that is used, unfortunately, is not dictated by our desire to separate

THE WITNESS: (cont'd.) the two materials. That's dictated by the refractive index of the filter. We have a simple filter and we are stuck at that point with the refractive index that we use.

DR. UFFEN: Just change the filter.

THE WITNESS: I don't know that you can do that.

DR. DUPRE: I'm going to try one more, Dr. McDonald...

THE WITNESS: Chatfield.

DR. DUPRE: I might say that I share the following with Dr. McDonald in the conference, which is that one of my points today has been that it appears that I have succeeded in asking questions that you understand, and then you give answers that only my colleagues understand.

Let me push my luck on one more point, and let me cast it at a greater level of generality.

One possible approach, of course, to standard setting is to have standards that differentiate by fiber type. Indeed the Ontario proposal is in that category. This kind of approach to standard setting, namely differentiation by fiber type, basically is an approach, as I take your testimony, that in order to be feasible has to depend on the right kind of measurement technology?

THE WITNESS: Yes.

DR. DUPRE: Now, let's take another possible approach to the standard setting. Here we would be looking at an approach to standard setting that distinguished among various phases of the asbestos industry. You have one standard for mines, one standard for textiles, let's say another standard for maintenance. Let's assume for the sake of the argument that we are not going to differentiate among fiber types, but we are just going to differentiate among the different sectors of the asbestos industry.

DR. DUPRE: (cont'd.) Now, if one were to take that kind of an approach to standard setting, would one also have to be very careful to select something like scanning electron microscopy to make that approach feasible, or is say your phase counting optical microscopy up to snuff for that approach?

THE WITNESS: I think what you are saying there is that the different sectors of the industry have a different size distribution, and therefore a phase contrast fiber count done in one sector of the industry means something different in terms of exposure of the individuals to what it does in another sector of the industry.

I think if you are going to vary the standard in these situations, personally I would like to see all fibers accounted for. Because if we persist with the phase contrast measurement, we just don't know what's going on in these sectors of the industry. It's a useful technique as a means of controlling dust, but as it says in the AIA...it's actually in the preface to the AIA method...it should be used in well-characterized situations.

The thing that's missing at the moment is the characterization of the workplace atmosphere by sophisticated methods, followed by a lot of routine testing. We just don't know what's there. There ought to be in some way built into the regulations some means of knowing that the situation is still the same as we think it is.

DR. DUPRE: Counsel?

MR. LASKIN: The scanning electron microscopy which you have just been describing, can it be utilized now in the workplace, or is it something different than the method you described earlier which was experimental?

THE WITNESS: Oh, it is different. It could be used today. There really is not particular difficulty in applying that technique.

MR. LASKIN: That's the one where you said the

MR. LASKIN: (cont'd.) cost estimate was about eighty thousand dollars for the capital equipment, with whatever computer linkage there had to be?

THE WITNESS: Yes, that's correct. Well, you wouldn't need the computer then if the counting was going to be done manually. Then this is an applicable device even now.

MR. LASKIN: In response to a question from Linda Jolley, I thought I heard you say that if you used the scanning electron microscope rather than the optical microscope, for the same sample, you would get a higher fiber count?

THE WITNESS: Yes.

MR. LASKIN: All right. When you gave that answer were you talking only about fibers greater than five microns in length, or did you give the answer because with the scanning electron microscope you would be measuring all the fibers?

THE WITNESS: Well, of course, the fibers that we miss optically, longer than five micrometers, the ones that we miss optically would be seen on the scanning microscope. So in other words we would have a higher longer-than-five count.

MR. LASKIN: I take it your answer depends on the fact that you are counting all of the fibers and not just specific index fibers, as with optical microscopy?

THE WITNESS: Well, we count all of them, but if you take the five micron, those longer than five micrometers, we are seeing all of them regardless of their diameters in the SEM, whereas we would not be seeing some of them, in fact a large proportion we would not be seeing by the optical method.

MR. LASKIN: Because of the detection capability of the optical microscope?

THE WITNESS: The diameter detection, yes, limits of resolution.

MR. LASKIN: That you told us about before. Okay. I just have one other area that I...

DR. DUPRE: I just wonder if Miss Jolley...did you want to...?

MISS JOLLEY: No, I was just going to point out to Mr. Laskin that the quote I actually had was from tab eighteen where it was..."Phase contrast optical microscope

> measurements record only two percent to twenty-five percent of the fibers of more than five microns in length"...

so that was actually what you and I, I think, were discussing, was more than five microns in length.

THE WITNESS: That's correct, yes.

MR. LASKIN: Just one other question I wanted to ask you.

When Dr. Nicholson was here a couple of weeks ago, he told us about some samples of urban air environments and the asbestos mass concentrations that he had got in several cities in the United States, and I think in fact you refer in one of your papers to that study. As I recall it basically, he found that those measurements ranged somewhere between about one and I think about a hundred nanograms. Can you give me any idea what that measurement would look like in a fiber count?

How does it...given the fact that Ontario has got a proposed guideline of point zero four fibers per milliliter, and let's assume for the purpose of this question that if you sampled cities in Ontario you would come up with the same calculations that Dr. Nicholson did, how would they compare with the proposed Ministry of Environment guideline?

THE WITNESS: I think they would be very comparable because the numbers that we have come across...we have seen numbers in the vicinity of one to seventy nanograms per cubic meter. This is by computation. In other words, a fiber

THE WITNESS: (cont'd.) count that is then converted to mass by some calculation of the total volume of fibers, and then multiplication by the density of the material.

This is very consistent with what we see.

MR. LASKIN: But then what is the parallel fiber count that you get for that kind of mass concentration?

THE WITNESS: It depends how big they are. This is the problem. In many of our reports you will see a statement that the fiber count is less than a certain number, and we decline to quote a mass concentration because you have to assume a fiber dimension in order to calculate a less than specific mass.

The numbers that we would normally think of, a total fiber count...I'm talking about chrysotile here...a total fiber count of perhaps point two fibers per milliliter would correspond to some tens of nanograms per cubic meter.

MR. LASKIN: The conversion...

THE WITNESS: As I say, that's an ambient air sample and that is using the kind of size distribution that we encounter.

MR. LASKIN: The conversion that Dr. Nicholson suggested to us in that setting, as I recall it, was a thousand nanograms per cubic meter would be equal to point zero three fibers per milliliter. Is that...do you have any...does that seem a reasonable conversion, from your own work?

THE WITNESS: I would have to go away and do some calculations. I couldn't give you it. I would have to give you that later.

These things are not easy because you have to take a complete size distribution of the kind you encounter, and then sum the thing up. It's easy enough to do with a computer but I can't do it here.

MR. LASKIN: Thanks very much, Dr. Chatfield.

DR. DUPRE: Dr. Chatfield, on behalf of all of us, thank you very much indeed. Once again we are in your debt. Thank you.

The summer school will now reconvene on Monday, July 20th at ten a.m. when Dr. Acheson will be the expert witness.

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THE INQUIRY ADJOURNED

THE FOREGOING WAS PREPARED
FROM THE TAPED RECORDINGS
OF THE INQUIRY PROCEEDINGS

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EDWINA MACHT